NOV 13 1923

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXVI.—No. 3018.] *LONDON: FRIDAY, NOVEMBER 2, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER.
Steam Road Rollers & Tractors.
1108

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
See half-page Advert. last week and next week. 1382

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell 1137

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos Piggott & Co., Limited,
BIRMINGHAM. 1241
See Advertisement last week, page 92.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 77.* 1283
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. **Boilers.**
See page 17. 1134

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester Od 9783

GEARS OF EVERY DESCRIPTION.
Spring Grove,
AUTOGEARS (LEEDS), LTD., Hyde Park Road, Leeds. 1743

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of 1834
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3.

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 77, Oct. 26.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1539

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 12 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3561
ENGINEERS & BOILER MAKERS.

Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD.,
REGENT WORKS, WAKEFIELD. 1668

OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2632.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 95, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Od 3353
3, VICTORIA STREET, WESTMINSTER, S.W.

MACHINE CUT
Gears.
Spurs, Bevels,
Spiral, Worm and
Worm Wheels.
HIGHFIELD GEAR CUTTING CO.
(DEPT. E),
Huddersfield. 1645

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Oct. 12.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 1366

John Bellamy, Limited,
MILLWALL, LONDON, E. 1210
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 58. 1111

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 55, Oct. 26.

Gearing for Power Transmission.
Including Machine Moulded GRAB WHEELS up to 10 feet dia.
FLY WHEELS (rope or spur drive) up to 28 feet dia.
IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
ENGINES: "Uniflow," "Corliss" or Drop Valve.
BREAKDOWN Repairs a speciality.
CLAYTON, GOODFELLOW & CO., LTD.,
Atlas Works, BLACKBURN. 1219

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
306, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7424. Od 865

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
'Phone: Hammersmith 31, 967. 9211

Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9866
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Machine Cut Gears
SPUR AND SPIRAL.
Worms and Worm Wheels.
Worm and Spur Reduction Sets.
High Grade Work at Reasonable Charges.
STORM & EVANS,
Grove Road, Hunslet, Leeds. 1573

Carels Diesel & Steam Engines.
CARELS DIESEL & STEAM ENGINES (LONDON) LTD., Kinnaird House, 1, Pall Mall East, S.W. 1. 1120
Telephone: Regent 3484.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8732

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1553

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, **Dumbarton.** 1433
See Full Page Advt., page 60, Oct. 12.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry Works, and Showrooms: BIRMINGHAM.
See advert., page 48, Oct. 12. 8196

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 58. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 1212

DAVID BROWN & SONS (Hudd.) Ltd.
Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

For Your Repairs or any
SPECIAL MACHINERY, try—
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 1642

Electric Cranes.
Traversers.
Transporters.
Lifts.
S. H. HEYWOOD & Co., LTD.,
Reddish. 1557

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 1670
See half-page Advertisement, page 74, Oct. 26.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

Correspondence Courses for Inst Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, Trafford Chambers, 58, South John Street, LIVERPOOL. 1206

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 393, Oxford Road, Manchester. 1723

Power and Speed of Vessels. —Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of Engineering.

TENDERS.

COUNTY OF LANARK.

DISTRICT OF THE MIDDLE WARD.

For Sale, Plant as under-
NOTED:—
ONE HIGH SPEED ENGINE (Vertical open type) 13 in. cylinder, 21 in. stroke, 80 lbs. steam pressure, made by Robey & Co., Lincoln. ONE SHUNT DYNAMO, 105 volts, 150 amps. made by Harvie & Co., Glasgow. ONE HIGH SPEED ENGINE (Vertical open type), 6 in. cylinder, 6 in. stroke, 80 lbs. steam pressure, made by Alexr. Shanks, Arbroath and London, coupled to dynamo (Shunt), 105 volts, 60 amps, made by Harvie & Co., Glasgow. ONE HIGH SPEED ENGINE (Vertical open type) 8 in cylinder, 9 in. stroke, 80 lbs. steam pressure (this engine is driving laundry plant), made by Sheils, Elliot & Nelson, Glasgow.
The plant is at the County Hospital, Motherwell, and will be shown to prospective buyers by the Resident Physician-Superintendent. Sealed Offers should be addressed to the Subscriber on or before 16th proximo.
The lowest or any Offer may not be accepted.
W. B. WHYTE,
District Clerk.
District Offices,
Hamilton,
29th October, 1923. C 39

STATE ELECTRICITY COMMISSION OF VICTORIA.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.
Specification No. 24/2. — TRANSFORMERS, SWITCHGEAR AND ACCESSORIES, SUB-STATION "B."
Charge:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawings complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each. This charge is not returnable.
Preliminary Deposit:—A Preliminary Deposit of £100 is to be lodged with Tender. The Specifications may be inspected at the above mentioned office. The Commission does not bind itself to accept the lowest or any Tender. Tenders on prescribed form properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Noon, 19th January, 1924.
R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. B 981

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,

are prepared to receive

Tenders for the Supply of:—

1. LOCOMOTIVE BOILERS.
2. WATER CRANES, Etc.
3. PLATE GLASS, Etc.
4. LINOLEUM.
5. CANVAS.
6. LAMP GLASSES, Etc.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Locomotive Boilers," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 30th November 1923, in respect of Specifications Nos. 1 and 2, and no later than Twelve Noon, on Friday, the 16th November, 1923, in respect of Specifications Nos. 3, 4, 5 and 6.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of £1 for each copy of Specification No. 1; of 5s. for each copy of Specifications Nos. 2, 3, 4 and 5; and of 2s. 6d. for each copy of Specification No. 6.
Copies of the Drawings may be obtained at the Offices of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.
A. MUIRHEAD,
Managing Director.
91, Petty France,
Westminster, S.W.1.
30th October, 1923. C 59

THE GREAT INDIAN PENINSULA RAILWAY COMPANY,

48, Copthall Avenue, London, E.C.2, invite

Tenders for Steam Coaling CRANES. For £1.
Tenders are due by Eleven a.m., on 20th November, 1923. Tender forms obtainable at above address. Fees not returnable. C 45

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

Contract No. 14.—New Aqueduct

The Town Council of Aberdeen are prepared to receive

Tenders from Competent Persons willing to enter into a Contract for the MANUFACTURE and DELIVERY of about 7 miles of 40 inch diameter PIPES and SPECIALS of the following alternative types, viz.:—
(a) Cast Iron.
(b) Mild Steel (Lapwelded).
(c) Reinforced Concrete (spun and ordinary).
The Drawings may be inspected and Specification, Schedule of Quantities and Form of Tender obtained, on and after 7th November, 1923, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable and no Specification will be given out after 16th November.
For each Specification a deposit of Five Pounds sterling will be required, which sum will, after a tender has been accepted, be returned to the tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification and Schedule of quantities provided, with the Schedule of quantities fully priced out in detail, and shall not have withdrawn the same.
The employment of labour shall be in accordance with the conditions of the Unemployment Grants Committee.
Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for NEW AQUEDUCT PIPING" are to be addressed to the undersigned. No Tender delivered after Five p.m. on 26th November, 1923, will be considered.
The Town Council do not bind themselves to accept the lowest or any Tender.
GEORGE MITCHELL M.Inst.C.E., F.G.S.,
Water Engineer.
Water Engineer's Office,
41½, Union Street, Aberdeen.
23rd October, 1923. B 962

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

Contracts Nos. 15 & 16.—New Aqueduct.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent Persons willing to enter into a Contract for the TRANSPORTING, LAYING and JOINTING of about 7 miles of 40 in. PIPING and ANCILIARY WORKS between CRATHES and CULTER.
The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 7th November, 1923, on application at the Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no Specification will be given out after 16th November.
For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a tender has been accepted, be returned to the tenderer, provided that he shall have sent in a *bona-fide* Tender, based on the drawings, specification and schedule of quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.
The employment of labour shall be in accordance with the conditions of the Unemployment Grants Committee.
Tenders on the Forms prescribed, and enclosed in securely sealed envelopes, endorsed "Tender for AQUEDUCT PIPELAYING" are to be addressed to the undersigned. No Tender delivered after Five p.m. on 26th November, 1923, will be considered.
The Town Council do not bind themselves to accept the lowest or any Tender.
No person should tender unless thoroughly experienced in the actual construction of extensive public works.
GEORGE MITCHELL, M.Inst.C.E., F.G.S.,
Water Engineer.
Water Engineer's Office,
41½ Union Street, Aberdeen.
23rd October, 1923. B 963

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND ERECTION OF TWO RECIPROCATING ENGINES AND PUMPS, at Kempton Park Pumping Station, Middlesex.

The Metropolitan Water Board invite

Tenders for the Supply and ERECTION of TWO TRIPLE EXPANSION DIRECT-ACTING RECIPROCATING, ROTARY TYPE, PUMPING ENGINES, Cylinders approximately 30in., 50in., and 86in. diameter, by 5ft. 6in. stroke, at their Kempton Park Pumping Station, Middlesex.
Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected without payment of fee at the Offices of the Board (Board 173), Chief Engineer's Department, 173, Rosebery Avenue, Clerkenwell, E.C.1, on and after Thursday, 1st November, 1923.
Contractors desirous of tendering may obtain the necessary documents from Mr. Bevan E. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of Three Guineas, which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona-fide* Tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board," and not to individuals.
Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C.1," and endorsed "Tender for Machinery, Kempton Park," must be delivered at the Offices of the Board not later than Ten a.m., on Monday, 31st December, 1923.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
173, Rosebery Avenue, E.C.1
22nd October, 1923. B 980

The Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—
1. VOLUTE and HELICAL SPRINGS.
2. COPPER PLATES for fire boxes.
3. WROUGHT IRON BOLTS and NUTS.
4. MILD STEEL RIVETS.

Tenders due on the 15th November, 1923.
Tender Forms obtainable from above. C 40

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon, on Friday, 23rd November,

Tenders for the Supply of:—

1. COVERED GOODS WAGONS.
2. WHEELS and AXLES for WAGONS.

Tenders must be made on forms, copies of which, with specification, can be obtained at these Offices on payment of 20/- each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W. 1.
31st October, 1923. C 67

GREAT NORTHERN RAILWAY (IRELAND).

TO BRIDGE CONTRACTORS.

The Directors are prepared to receive

Tenders for Reconstruction of a STEEL VIADUCT at Annaghkilly, between Newbliss and Clones.
The Drawings and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Bills of Quantities and Forms of Tender, may be obtained from the undersigned on payment of Two Guineas, which will be refunded on receipt of a *bona fide* Tender, accompanied by the drawings.
Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover, endorsed "Tender for Bridgework," not later than Ten a.m., on Saturday, 17th November.
The Directors do not bind themselves to accept the lowest, or any tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station, Dublin,
30th October, 1923. C 44

GREAT NORTHERN RAILWAY (IRELAND).

TENDERS FOR LOCOMOTIVES.

The Directors are prepared to receive

Tenders for:—

FIVE GOODS ENGINES, with TENDERS;
and
FIVE TANK ENGINES.

In accordance with the Company's Drawings and Specifications, copies of which can be obtained on application to the undersigned, upon payment of £2, which will be refunded on receipt of a *bona fide* Tender, and return of the Drawings and Specifications.
Tenders, made out on the forms supplied by the Company, should be delivered, under sealed cover endorsed, "Tender for Locomotives," not later than Ten a.m., on December 3rd.
The Directors do not bind themselves to accept the lowest, or any Tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station, Dublin,
31st October, 1923 C 54

PORT OF BRISTOL.

CONSTRUCTION OF EASTERN ARM OF ROYAL EDWARD DOCK.

PRELIMINARY NOTICE.

The Docks Committee expect to shortly invite

Tenders for the Construction of the EASTERN ARM of the ROYAL EDWARD DOCK, AVONMOUTH.
The work will consist principally of the removal and carrying to spoil of the main excavation for the arm of the Dock, together with the construction of a ferro concrete built Wharf about 1700 ft. long on each side. Also the construction of two three-floor ferro-concrete built Transit Sheds, each 500 ft. long; and a ferro-concrete built Silo Granary of about 6000 tons capacity.
The complete plans and specification will be ready early in December; but in order to provide employment at the earliest possible date, it will be necessary that the Tenders should be received early in January. This preliminary notice is, therefore, issued so that intending tenderers may make an inspection of the site as soon as possible after Monday, 12th November, when they can obtain such of the Drawings and Schedules of Prices as may be ready at the time.
The complete Specification, Schedules of Prices and Contract Drawings will be sent early in December to all applicants, on production of a receipt showing that a deposit of £15 has been paid to the Bristol Docks Committee, 19, Queen Square, Bristol, to whom all cheques must be made payable the deposit of £15 will be returned hereafter to all *bona fide* tenderers.
Communications for an inspection of the site, etc., should be sent to the undersigned as early as possible.
The Docks Committee do not bind themselves to accept the lowest or any Tender.
THOMAS A. PEACH,
Chief Engineer,
Port of Bristol.
Chief Engineer's Office,
Avonmouth Docks,
31st October, 1923. C 65

APPOINTMENTS OPEN.

Required, Steam Engineer, to take charge entire boiler plant large paper mills at Grand Falls, Newfoundland. Must be thoroughly experienced in large stationary steam plant and be familiar with return tubular and water tubular boilers and Automatic stokers. Experience paper mill work useful but not essential.—Apply, by letter, stating qualifications and salary required to ANGLO-NEWFOUNDLAND DEVELOPMENT CO., Ltd., 16-17, New Bridge Street, London, E.C. 4. C 61

Wanted, Assistant Works MANAGER in Company employing 2000 to 3000 hands near London. Must have had first-class experience on fine tool work, high grade mass production of mechanical and cabinet work and be conversant with latest shop methods and organization. Only Engineers having these qualifications and executive ability need apply.
Adequate salary will be paid.—Address, stating age and experience, C 55, Offices of Engineering.

SURREY COUNTY COUNCIL.

HIGHWAYS AND BRIDGES DEPARTMENT.

Applications are Invited for THE APPOINTMENT OF SECOND ENGINEERING ASSISTANT at a salary commencing at £190 per annum, rising by annual increments of £10 to £230 per annum. The appointment will be terminable by a month's notice on either side, and will be subject to the provisions of the Local Government Officers Superannuation Act, 1922. Applicants should be competent to make surveys, take levels, and assist with Bills of Quantities and Specifications, and preference will be given to candidates holding the Testamur of the Institution of Municipal and County Engineers. Applications in writing, accompanied by copies of three recent testimonials, should reach W. P. Robinson, Esq., A.M.I.C.E., County Surveyor, County Hall, Kingston-on-Thames, not later than Monday, the 26th November, 1923.
T. W. WERDING,
Clerk of the County Council.
County Hall,
Kingston-on-Thames.
27th October, 1923. C 35

Wanted a Good Trained Mechanic with considerable experience in Testing and Running Semi-Diesel Engines, and capable of erecting engines on site and starting up, state age, experience and full particulars.—Address, C 61, Offices of Engineering.

Wanted, First-Class Man for Important Executive Position in large Engineering Works. Must be experienced tool maker, with good technical training in modern tool designing for mass production.—Address, EXECUTIVE, Wm. Porteous & Co., Advertising Agents, Glasgow. C 19

The Royal Air Force REQUIRES SKILLED FITTERS General (for training as Aero Engine Fitters), Fitters Driver Petrol, Electrical Fitters and Power Station tradesmen. Age limits:—Ex-Service men 18 to 30; Non-Ex-Service 18 to 28; highly skilled Fitters up to 35. Ex-N.C.O's up to 38 years (with rank according to trade ability). Pay from 21s. to 66s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, W.C. 2. B 799

An Electrical Instrument Co., London district, HAVE A VACANCY in Test Room for CHIEF ASSISTANT; executive ability and previous experience on accurate instrument work essential.—Address, giving full particulars, C 41, Offices of Engineering.

Wanted, Electrical Engineer to take full charge of power plant, East Africa, 1100 Kw. Turbo Generator (Ljungstrom), boiler house, and about 25 motors. For particulars apply ROOM 31, Temple House, Tallis St., London. C 14

The Advertisers thank Applicants for Positions as Maintenance Mechanics as advertised in issue of October 12th, under Box No. B 879, and have to inform them that the vacancies are now filled. C 17

Selling Engineer for Well- known medium Compression Oil Engines. London District. Good appearance essential. Give full particulars.—Address, C 34, Offices of Engineering.

Required, Young Construction ENGINEER-DRAUGHTSMAN, knowledge furnace work and estimating, also French language desirable, as assistant to consulting engineer, to start work about Nov. 15th, centre London. State experience, salary required, full particulars.—Address, B 964, Offices of Engineering.

Reinforced Concrete DRAUGHTSMAN REQUIRED for Preparing Reinforcement details. Good structural steel man might suit.—Address, with full particulars, C 11, Offices of Engineering.

Draughtsman Required for few months, capable of designing simple machines and producing working drawings, tracings. Possible permanency if salesmanship combined with technical qualifications.—C 26, Offices of Engineering.

Draughtsman for Air- screw Design REQUIRED at the Royal Aircraft Establishment. Must have good technical and works training and actual experience of Airscrew work. Salary about 70s. per week, plus cost of living bonus, giving a present total of 108s. 5d.—Apply (quoting A.2), with full particulars, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. C 57

Draughtsmen Required for the Midlands, with experience in Gas Plants, state age, salary required.—Address, C 32, Offices of Engineering.

Experienced Draughtsmen REQUIRED for temporary positions, accustomed to the designing of girder work and other constructional work, calculations of stresses, etc.—Apply, by letter, to W. H. WILLIAMS, Divisional Engineer's Office, L.M. & S. Railway, Crewe, stating age, experience, and salary required. C 18

Wanted, First-class Draughts- man with up-to-date experience in Hydraulic Machine Tools and Rubber Machinery.—Apply, giving particulars of experience, age and salary required, to HENRY BERRY & Co., LTD., Leeds. None but fully qualified men need apply. C 8

, 1923.

Works
y employing
ust have had
k, high grade
cabinet work
methods and
these qualifi-
ply.
dress, stating
NGINEERING.

ICIL.

EPARTMENT.

vited for
F SECOND
a salary com-
ng by annual
annum. The
months notice
the provisions
superannuation
competent to
with Bills of
reference will
statutes of the
ty Engineer,
by copies of
reach W. P.
nty Surveyor,
not later than

y Council.

Trained
experience in
Engines, and
d starting up.
lars.—Address,

Man for
in large Engi-
ool maker, with
designing for
UCTIVE, Wm.
Glasgow. C 18

r Force
ED FITTERS
Aero Engine
ctrical Fitters
e limits:—Ex-
vice 18 to 25;
-N.C.O's up to
e ability). Pay
ament, and all
ren to men 28
-INSPECTOR
rietta Street,
B 750

ment Co.,
VACANCY in
T; executive
curate instru-
giving full
ING.

Engineer
t, East Africa,
strom), boiler
rticulars apply
ondon. C 74

thank
Maintenance
October 12th,
rm them that
C 17

r Well-
Oil Engines.
ssential. Give
of ENGINEER-

struction
, knowledge
nch language
engineer, to
ondon. State
particulars.—
s.

ncrete
for Prepar-
ructural steel
l particulars.

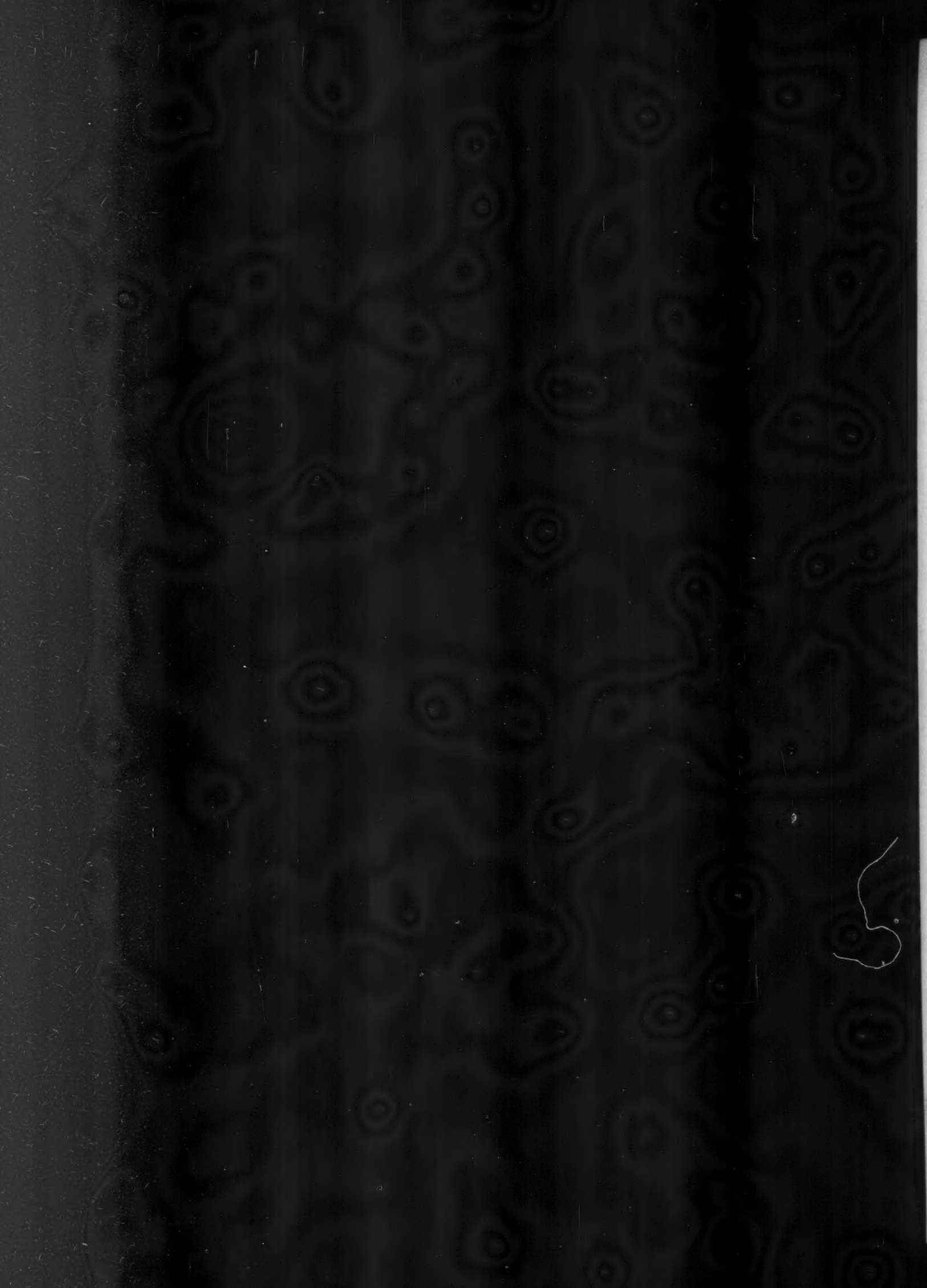
edforfew
mple machines
ings. Possible
d with techni-
GINEERING.

for Air-
IRED at the
s. Must have
and actual
ry about 7os.
us, giving a
quoting A 22),
NTENDENT.
C 37

ired for
n Gas Plants.
C 32, Offices of

ghtsmen
aitions, accu-
ork and other
stresses, etc.
18, Divisional
Crewe, stating
C 16

raughts-
perience in
Machinery.—
nce, age and
& Co., LTD.,
need apply.
C 49



THE CONSTRUCTION OF A REINFORCED CONCRETE WORKSHOP BUILDING AT ELSINORE.

THE shipyard and buildings of the Elsinore Shipbuilding and Engineering Company were laid out and built originally by British engineers in 1882–83, and for that date the yard with its docks, berths, patent slipway and workshops was comparatively large, the facilities and the accommodation being adequate in every sense. During the forty years which have since elapsed the business of the firm has greatly developed, so that to-day the area is very restricted for the work carried on, and operations are considerably hampered through the lack of space. Although improved several times since 1882 the plant and buildings had recently got rather out of date, and while this could not be rectified during the boom in shipbuilding which immediately followed the war it was evident, when work become more slack, that if the firm was to compete successfully with the new concerns started during the war, the Elsinore yard would have to be partly remodelled. The work taken in hand as a consequence of this included the reconstruction and enlargement of the workshops, which it was decided to replace by a much larger building, the construction of which is illustrated in Figs. 1 to 21 on the present page and on pages 548, 549, 550 and 562.

The designing and construction of this building was placed in the hands of Messrs. Saxild and Partners, 2, Central Buildings, Westminster, and the building was carried out in reinforced concrete. The conditions of the site and the restrictions under which the building was erected have resulted in a number of interesting features which we propose to deal with, while the actual work of erection also embraced rather unusual arrangements. The new workshop, of which a plan is given in Fig. 1, is a building 334 ft. long and about 131 ft. wide, divided into three longitudinal bays. Of these the two outer are about 54 ft. each and of two storeys, while the centre bay is more lofty, but of 23 ft. width only. These dimensions of themselves represent, of course, nothing very formidable, but the design was rendered much more complex by the fact that the shipbuilding company insisted that the sites for the columns should be located rather with a view to facilitating work at machines which it was intended to install, than according to the best position from the building point of view. This preference given to shop operation resulted in a very irregular spacing of the columns, of which there were allowed only six intermediates in the longest side, while very few of them lined off across the building. Some of the spans between the columns thus had to be as long as 80 ft. and no two girders are alike.

Fig. 1.

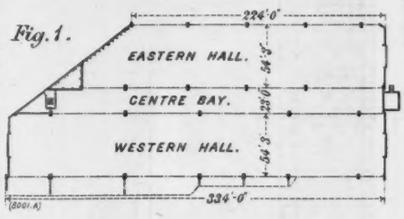


Fig. 2.

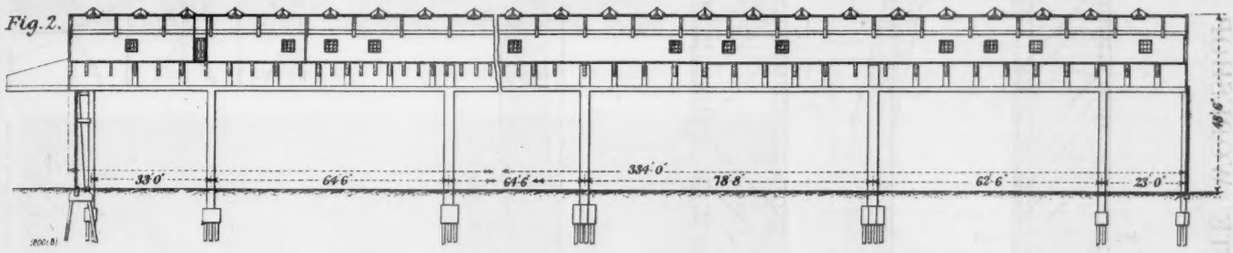
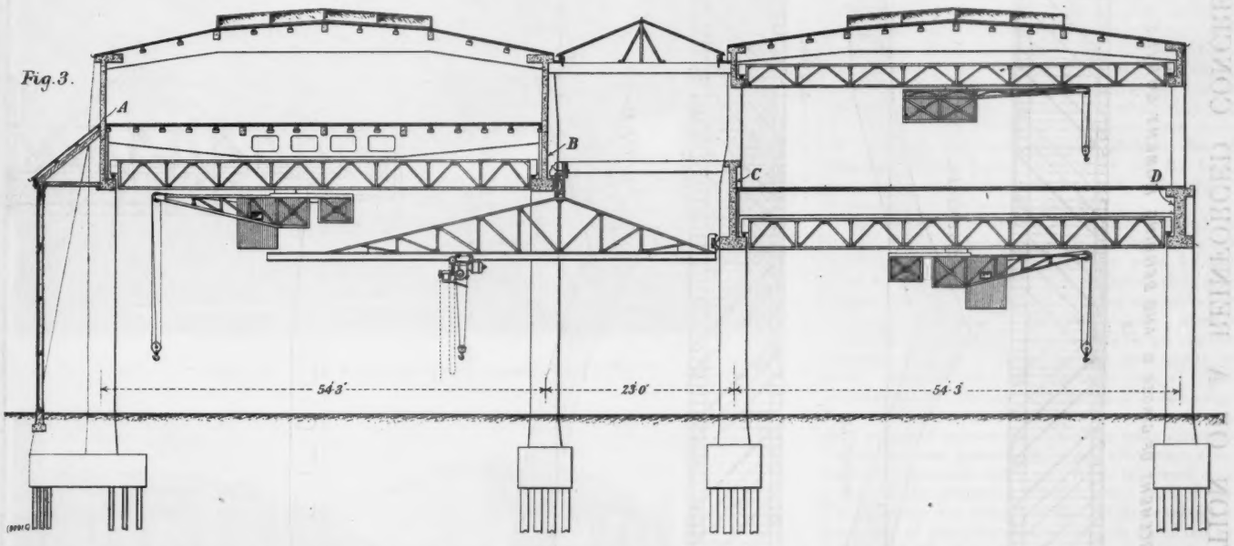


Fig. 3.



Moreover, as the local authorities limited the maximum height of the building to 49 ft., and as the company needed the greatest possible head room for cranes, &c., the structural depth of all members, both longitudinal and transverse had to be restricted to the minimum. The building thus affords an interesting example of the use of girders of large span and of minimum depth.

A longitudinal section of the building is shown in Fig. 2, while in Fig. 3 is given a cross-section. From these the main structural features will be clear, the principal members being a series of longitudinal girders shown at A, B, C and D (Fig. 3). These series of girders are carried by four ranges of rectangular columns standing on mass concrete foundations on timber piles. The concrete of the foundation blocks is carried down to below the lowest water level so that the piles are always under water. In the case of the girders A and B it was possible, as the sides of the upper storey of this bay were to be closed, to make full use of the depth available and combine the construction of the girder with the necessary walls. The depth, therefore, of these girders is 16 ft., the web constituting the walls being 8 in. thick, while the top flanges are 48 in. wide and 12 in. thick. The bottom flanges are 24 in. wide and 16 in. thick, and carry the track of an overhead travelling crane for the large bay. The girder B also supports a crane track on the side facing the central bay. The character of the work may be gauged by the fact that a vertical section of the A girder for the 80-ft. span shows 20 reinforcing bars, 1·0 in. in diameter.

In the case of the girders C and D the depth was limited as the sides of the upper storey of this bay had to be left open. The former girders were thus restricted to a depth of 11 ft., and the latter to 7 ft. 6 in. The flanges of the girders had to be made very heavy in order to give sufficient area for compression, and also to give space enough for the reinforcement required on the tension side. The reinforcement introduced into the D line of girders is shown in Fig. 4, page 548, and the small cross-sections given in Figs. 5 to 9, taken at various points of the length marked in Fig. 4. This girder has a thickness of web of 11 in., and width of flange of 3 ft. 6 in., the bottom flange being 16 in. deep and the top 12 in. deep. The heavy amount of reinforcement in this girder is well illustrated in the photograph reproduced in Fig. 12, on page 549.

The upper floor in the western bay consists of 1½ in. planking laid directly on reinforced concrete beams spanning the bay between girders A and B, into which the floor girders are bonded. A view of the upper floor of the eastern bay is given in Fig. 13, page 549. The flooring is of 1 in. planking laid on slab reinforced concrete, 4 in. thick, supported by reinforced beams extending between the girders C and D. The whole building is covered by a wooden roof carried on reinforced concrete principals, and overlaid with heavy roofing felt. Ample skylight area is provided. The eastern side of the building is quite open, sliding doors alone being provided for the upper storey. On the west side the building is closed by a wall of planking carried by steel framing. The ends of the building are closed by reinforced concrete walls, in which openings were left for very large sliding doors. Fig. 14 illustrates part of the north end of the finished building, and incidentally shows reinforced concrete cantilever prolongations

THE CONSTRUCTION OF A REINFORCED CONCRETE WORKSHOP AT ELSINORE.

Fig. 4. REINFORCEMENT OF GIRDER "D" AND BENDING MOMENT CURVES.

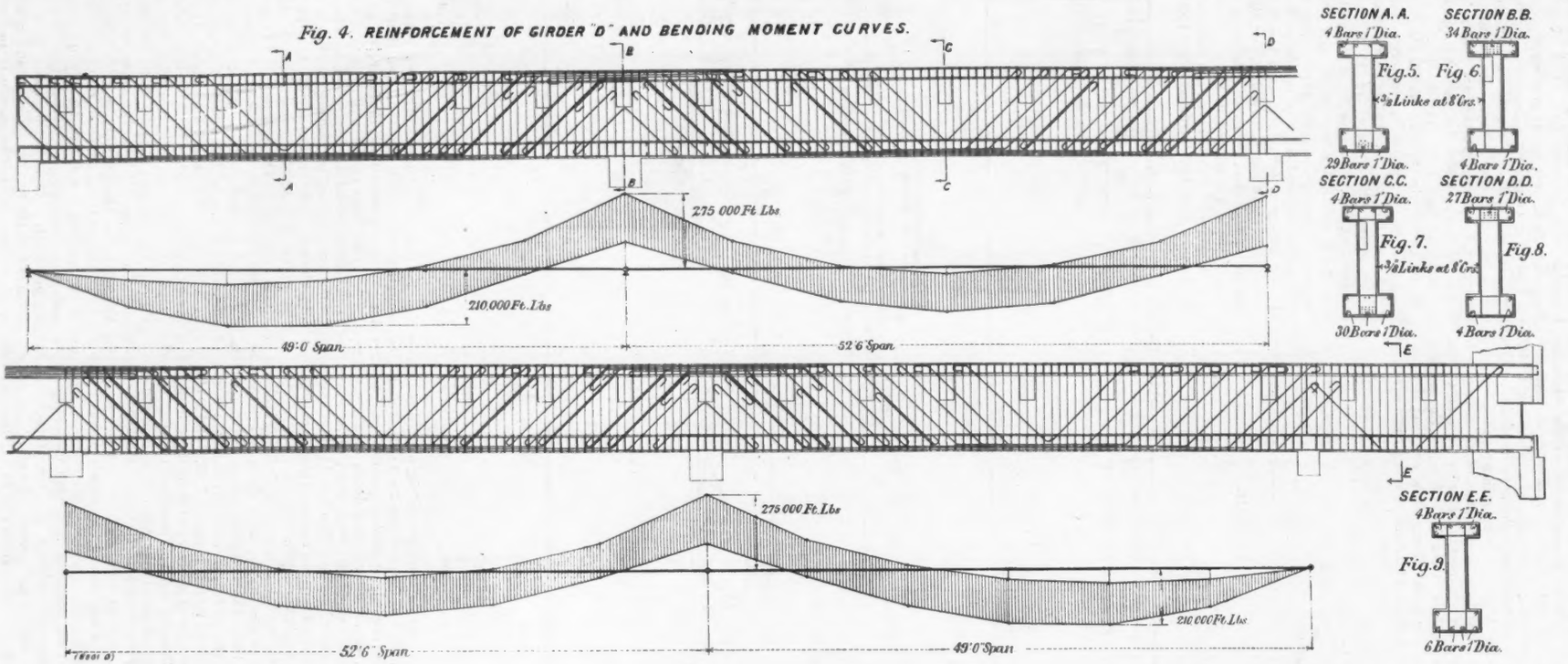


Fig. 10.

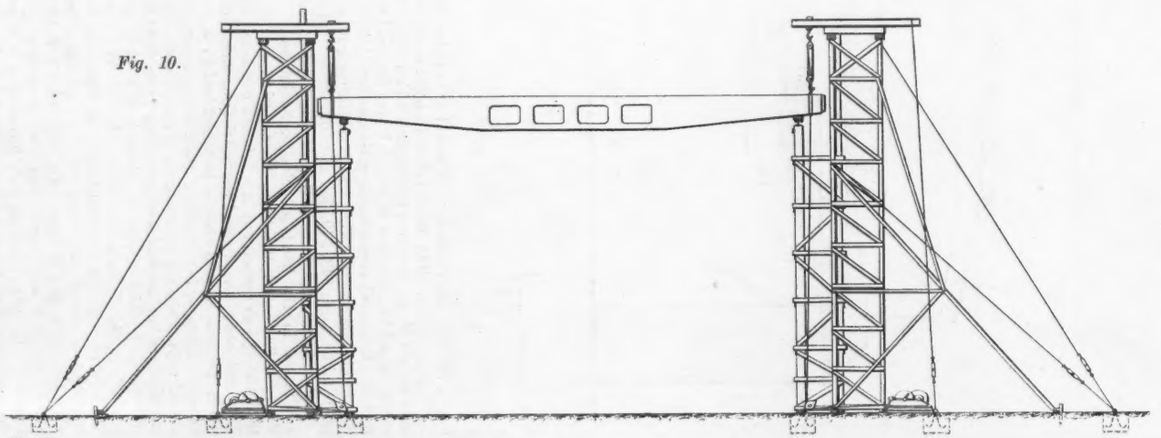
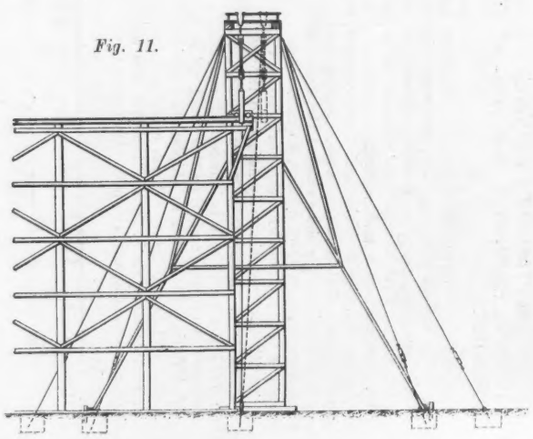


Fig. 11.



REINFORCED CONCRETE WORKSHOPS AT ELSINORE.

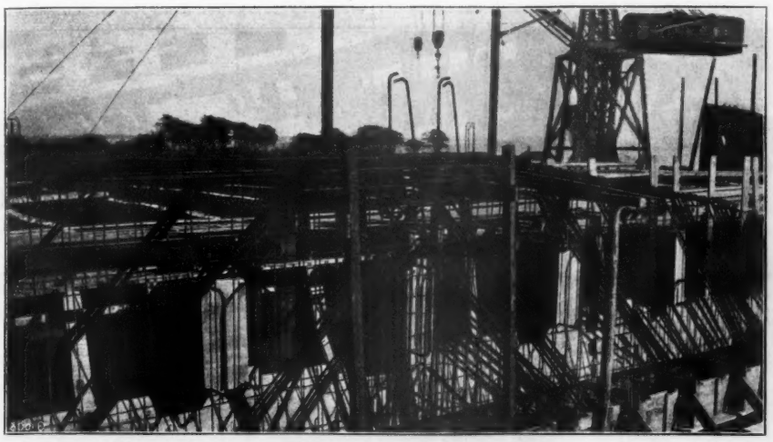


FIG. 12. REINFORCEMENT OF ONE OF THE MAIN GIRDERS.

FIG. 13. THE MOULDING LOFT COMPLETED.

FIG. 14. NORTH END OF THE COMPLETED BUILDING.

of the girders A and B, carrying the track for the crane operating in the western bay, which is thus enabled to run out over the yard space and pick up or deposit its load outside the shop floor area. Owing to the irregular placing of the columns a properly framed structure could not be designed, and the lateral rigidity of the building by itself is somewhat limited. As the site is exposed to high winds it was necessary to make special provision for dealing with wind pressure by enlarging the width of the foundations for the columns for the A girder, and running up from these large buttresses or struts of reinforced concrete. This arrangement is shown in Fig. 3.

The loads for which the structure was calculated were as follows: For the roof, snow and wind were allowed for according to the usual rules. Floor loads in the eastern and western bays were taken to be $1\frac{1}{2}$ cwt. and $\frac{3}{4}$ cwt. per square foot, respectively. In addition, as shown in Fig. 3, the main girders had to carry travelling cranes, four in number, and the heaviest of these weighed about 40 tons. The bending moments and shearing forces in the girders were obtained by the tracing of the influence lines for the different points in all the girders. In Fig. 4 is shown the distribution of the bending moment in the case of the girder D. This curve gives the limits between which the bending moment at all points on the beam can actually vary.

As already mentioned, owing to the circumstances under which the building was erected, its acutal construction presented even more interesting features than its design. The area of the yard was confined, and only a very small area could be allowed for the use of the contractor. The regular work of the yard had to be continued without interruption, so the idea of first demolishing the old building was out of the question. The new building was, as a matter of fact, constructed over the old, which was subsequently removed, work being continued throughout the operation. The old shop was in such a condition that it could not be utilised in any way even to support shuttering for the new work, so that it was necessary to pre-cast on the ground all the cross-girders for the two floors of the upper storey. Above this level in the two outer bays these floors themselves afforded support for the shuttering for the roof principals, &c., which were therefore cast *in situ*. Owing to the length of the floor beams, and the height to which they had to be lifted, very careful arrangements were made so that they should be handled without risk of damage. These beams were over 50 ft. long, and in the case of the west bay had to be placed in position 36 ft. above the ground.

The columns, as already stated, are founded on timber piles which had to be driven inside the old building. In many instances they were located close to machines in use, and as their length was greater than the height of the building pits had to be excavated, in which the piles were driven. Special light pile driver frames were employed with electric winches so as to facilitate moving from point to point. Most of this work had to be done at night in order not to interfere with the work of the shop. Two pile-drivers were in use at a time, and as soon as a group of piles was driven the mass concrete foundation was poured and work afterwards continued on the main columns. While this work was going on, the shuttering for the lower part of the main girders was being erected. This involved a good deal of complicated timbering in order not to put important machines out of use. A typical case is shown in Fig. 15, page 550. The lower part of these girders was then concreted, after which the cross-girders were hoisted and placed in position. These, in the meantime, had been pre-cast on a small area close to the work as shown in Fig. 18, page 562. The space available was so small that these girders had to be cast one over the other in layers four deep. They were all 52 ft. long and 3 ft. deep, with a thickness of 8 in. only. They were cast on the side and great care had to be exercised in righting them and removing them when matured. The longitudinal reinforcing bars projected from both ends to be tied in to the work of the main girders, and the stirrups also projected so as to connect up with the floor slab in the case of the eastern bay.

In order to place these members in position scaffolding was erected all down the bays, and two hoisting towers were built at the end nearest the moulding ground. This arrangement is illustrated in Figs. 10 and 11, page 548, and is also well shown in the views Figs. 18 and 19, page 562. The towers were provided with hoisting tackle operated by electric winches. The beams were run on trolleys

REINFORCED CONCRETE WORKSHOPS AT ELSINORE.

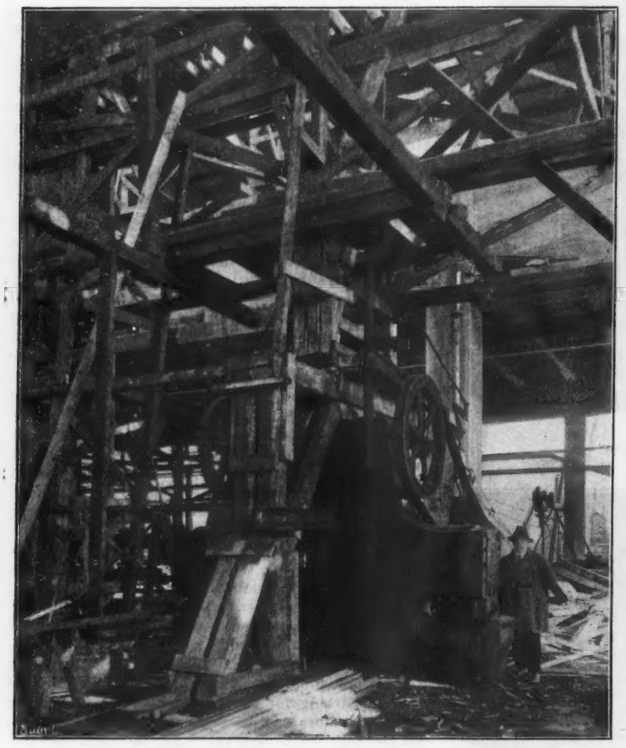


Fig. 15. Timbering Carrying Shuttering for Main Girders.

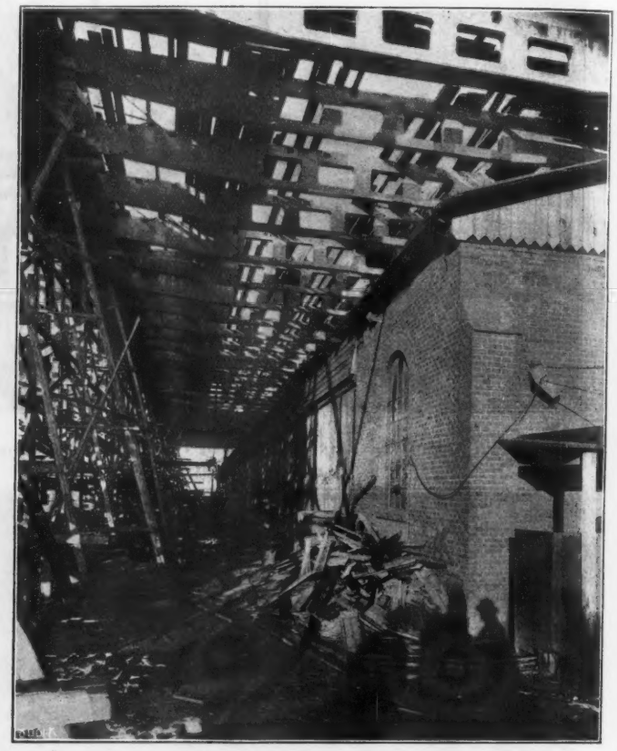


Fig. 16. Floorbeams placed in Position over Old Building.

from the moulding yard to a position between the two towers. They were next hoisted to the height required, and the tackle was then traversed a couple of feet, as will be clear from Fig. 11. This movement brought the beams over the ends of longitudinal joists laid on the top of the scaffolding, and they were next lowered out on to small trolleys and hauled on these by winches down the shop to the position each was to occupy. On arrival at the exact point the beams were lifted by chains and lowered on to the joists. Figs. 18 and 19, page 562, show this operation at two stages of the work, Fig. 19 being a view taken when nearly all the girders had been placed in position. When resting on the joists the pre-cast members projected 6 in. into the main girders, thus giving good connection. The ends of the beams are to be seen in Fig. 12, through the reinforcement. The next operation was the completion of the shuttering for the main girders and the pouring of the remaining portion of these members. The concrete slab flooring was completed, employing forms suspended from the floor beams themselves. The views Figs. 20 and 21, page 562, show the two sides of the building at different stages. The former shows the buttresses referred to previously, and the shuttering necessitated by the deep A girders. The latter illustration shows the construction of the upper storey on the east side. Both the upper storeys were completed in the usual way with shuttering built up, and the members cast in place. Fig. 13, previously referred to, gives a good idea of the moulding loft when finished. The central bay as completed is depicted in Fig. 17. Originally it was intended to pre-cast the beams for this, but owing to lack of space in the yard it was finally decided to construct the whole in the ordinary way with shuttering in place.

The manner in which the new building was erected over the old is well illustrated by Fig. 16, and the four illustrations, Figs. 18 to 21, on page 562. In spite of this, such great care was taken over the work that not the slightest accident occurred although about 100 men were employed on the work itself,

Fig. 17. Centre Bay of New Building Completed.

and about 300 were constantly working underneath. The time occupied for the whole contract was about nine months, but part of the building was taken into use by the shipyard only four months after starting actual construction.

THE SCIENTIFIC AND INDUSTRIAL RESEARCH DEPARTMENT IN 1922-3.

THE eighth annual report of the Department of Scientific and Industrial Research, covering the period from August 1, 1922, to July 31, 1923, which has lately been issued (H.M. Stationery Office, 4*s.* net), differs in arrangement from its predecessors, and affords a clearer view of its subject-matter. The actual report of the Department, which technically is a Privy Council Committee, to the King in Council, is enlarged so as to include a general statement of what the Department has done, spent, and has in contemplation. The appended report of its Advisory Council sets out the various questions of scientific policy that it has had to consider, analysed under much more detailed headings, and the conclusions at which it has arrived and on which it has advised the Department. The actual work done under each heading, which in previous years was included in the report of the Council, is now presented in a separate summary, of about the same length as the two reports put together; and as in previous years appendices give particulars of the membership of the Department's nine boards and its, or their, 32 committees for various classes of work (not including sub-committees with still more specialised objects), and of grants, aided researches, consequent publications, Imperial developments, research associations and Departmental publications, together with a copy of recent French legislation establishing a body similar to the department. The index appears thoroughly adequate to the text, having regard not only to its subject-matter but to the orderly manner in which it is presented, though for many of the Board's publications a more closely analytical form would be desirable.

The Department's constitution makes its proceedings of the more public interest because its *personnel* consists largely of members of the public, chosen for their distinction in scientific matters, which in some instances is combined with eminence in some branch of industry and in the conduct of business affairs. With the advantage, therefore, of a civil service nucleus and of such economy as results from Treasury control it combines that of being constantly recruited from the ranks of science and industry, and of representing these activities more directly and with a greater immunity from red tape than could be expected in a Government department of a more normal type. This feature is emphasised in the composition not only of the Advisory Council, whose advice appears in practice to be a condition precedent of action by the Department, but also of the numerous boards and committees to whom the Council delegates the task of preparing programmes of research in each field of work, of submitting estimates of cost, and, when these have been approved, of supervising the conduct of the investigations.

In this way the Council itself is left free to formulate and supervise the policy of co-operative research by the industries, to elaborate plans for Government research for the many years ahead that are often necessary, and to help by well-considered grants the labours of learned and professional societies, of students, and of individual research workers. It would perhaps be difficult to name a Government authority in which the same volume of gratuitous service is rendered by the public itself, and that bases its policy and administrative action so freely on the conclusions of eminent public representatives. In the year under notice this important aspect of the Department's constitution is said to have been of particular value in maintaining the co-operation of universities and scientific societies in its work, in co-ordinating the research work of the Department and the fighting services, and generally in securing the allocation of "border-line" investigations, preventing overlapping, and providing for due co-operation between bodies and authorities engaged on research.

In accordance with recommendations by the Advisory Council the Department has now decided the lines on which it will act in regard to industrial research associations who have reached the end of the five years for which their pound for pound grant was made. The considerations in question are discussed in the report of the Advisory Council, but the Department gives formal warning that further financial assistance will only be given subject to ample proof that the industry both cannot yet shoulder the entire burden of its research, and is prepared to make an immediate and rapidly increasing effort to that end. The Department is firmly resolved that its help must be given as an interim measure, taken only when there is a reasonable prospect that the industry will be able within a limited time to conduct its research quite independently of the State. In view of the fact that the fund of 1,000,000*l.* out of which these grants have to come has already been largely hypothecated, and may be further drawn on by new associations of which the formation is now under discussion, it is notified that existing associations wishing further help at the end of their current five years should enter into preliminary negotiations with the least possible delay.

The most notable event in the year's history of the Research Boards has been the resignation by Sir George Beilby of his offices as Director of Fuel Research and Chairman of the Fuel Research Board, which he has held since the formation of the Board early in 1917. The present report discloses, what has long been an open secret, that he has throughout been "the directing brain" of the Board's work, and it is not surprising that its onerous duties, following on his service as a member of Lord Fisher's Board of Invention and Research and as Chairman of the Trench Warfare Committee, are more than he is prepared to continue. He remains on the Department's Advisory Council, and has accepted the office of Adviser to the Fuel Research Board, a post which, like all his other service to the Department, will be honorary, at least so long as he holds it. The remarkable Fuel Research Station at Greenwich will remain a tangible monument of his farseeing insight and practical methods; but the researches that he has initiated into problems of coal, alcohol, and other fuels, the fundamental research by which he has given low-temperature carbonisation the assured scientific basis that it has so badly needed, and the manner in which he solved for the Board of Trade the difficult problem of finding an equitable method of charging for town gas, may prove ultimately to give no less striking evidence of the broad, cautious and accurate views that he has brought to bear on the Board's work.

With his retirement steps have been taken to enlarge the membership of the Board and develop its mechanism. The other members of the Board were Sir Charles Parsons and Sir Richard Threlfall, with himself an unusual combination of men of whom each is eminent in the three separate fields of science, industry and business; and doubtless the Board's work has not been laid out the less effectively because the wedge used for opening it up was not only keen but thin. It was thought, however, that with the resignation of Sir George Beilby the time had come for a more elaborate *personnel*; and while Sir Richard Threlfall becomes chairman and Sir Charles Parsons remains a member, six other members have been appointed with appropriate scientific and business credentials. Dr. C. H. Lander, who had hitherto been Assistant to the Director, as well as Acting-Director during the director's enforced absence for some months, has now been appointed Director of Fuel Research, and will have the assistance of small panels of experts to advise him in problems affecting particular industries or groups of industries. It is understood that these changes have been made on Sir George Beilby's express advice, and with his own offices in the hands of colleagues with whom he had been associated intimately on the Board's work, it may be expected with confidence that the intended developments will not be made at the expense of the traditions by which the Board and its officers have been inspired hitherto.

In addition to its own work the Board has been asked for help and advice by various industrial interests, and bulk consignments of coal have been sent for experiment at the Greenwich Station. Tests have also been made for Colonial Governments on coals and lignites.

As the result of work done by the Building Research Board the Department suggested in 1921 to the British Engineering Standards Association to add to the specification for Portland cement an alternative specification for the so-called iron Portland cement. This has now been done, and it is believed that it will be followed by a whole series of cements of the Portland group, made from a wide range of raw materials, each with some special quality, but all useful for building and civil engineering work. Experience, for instance, with the new bauxite cement, which the Building Research Board is actively studying, seems to show that it may be a strong competitor of Portland cement for some of its most important purposes, and such competition is not only likely to increase the range of alternatives and reduce the cost of building materials, but may also lead to technical improvement among Portland cement makers.

Other particulars are given of the Department's proceedings during the year, and of its relations with other bodies having similar objects, though the most interesting information on such matters is to be found in the Advisory Council's report. What, however, has to be gathered from the Department's own report is the financial aspect of its work, in regard to which figures are given under the heads of its several activities. When these are compared with the corresponding figures of earlier years it becomes evident that the artificial restriction of expenditure below what is required for researches of immediate urgency is being continued, and the situation so disclosed seems to be one of considerable gravity, when account is taken of the issues that may turn on maintaining the technical progress of industry and the timely development of national resources.

It will be remembered that the Department was instituted at the end of the first year of the war, and for the first three years of its history its industrial operations were necessarily hampered by war needs and circumstances. A large part of its intended operations referred to research of national importance or of such magnitude as would prevent it from being undertaken by other bodies, and both for this reason and because of the need to train research workers in much greater numbers than were available, even after demobilisation, the most important parts of its programme had to be drawn for considerable periods ahead, and to be based on the assumption that as researches that had been initiated emerged from their earlier stages, and as competent research workers became available in numbers more proportionate to the needs of the work, the extent of the researches under way would for some years be continually increasing. Without counting grants to research associations out of the capital of the fund voted by Parliament in 1916 for that purpose, the Department's net expenditure from public funds in 1920–21 was, in round figures, 427,000*l.* When this sum is compared with the 10,000,000 dols. that at the same time was estimated to be the annual expenditure of the United States authorities on research, in addition to a further 20,000,000 dols. estimated to be spent by private enterprise, and when the position of the United States as a competitor with our industries is remembered, it appears that either the United States is grossly extravagant in its provision for research and must be spending on it far more than can be profitable, or the British provision as measured by the Department's expenditure for 1920–21 cannot have been more than adequate, even after making the fullest reasonable allowance for research work done by other authorities.

That the expenditure was amazingly small in relation to the field of the Department's responsibilities is sufficiently evident from examining the plain statement of its work to be found in the present and previous reports. What its relation may ultimately be to the industrial gain from its researches can obviously not be estimated with any fullness until a sufficient time has been allowed for results to be obtained and applied; but the order of magnitude of its direct value is sufficiently suggested in some of the Fuel Research Board's results, which have established the means of economising coal in existing installations to a value

at the least comparable with the total expenditure not merely of the Board but of the entire Department.

Accordingly it appears beyond question that the amount spent in 1920–21, if applied to later years, in which existing researches should be developing and the other responsibilities of the Department would be expected to have increased, would be inadequate to its real needs; and while all practicable economy in public expenditure that could be made safely was of urgent importance, economy in what may be compared with the expense of seed for future harvests or insurance of future trade would be literally an extravagance. The figures given in the present report and its two predecessors show that this extravagance has been allowed. Whatsoever may have been the right provision for the Department's expenditure after 1920–21, it must to be economical have been something larger than in that year. As a fact, however, it has become substantially less. In response to Government instructions the programme for 1921–22 was first reduced by some 17 per cent., and in response to further Treasury instructions the estimates for 1922–23 were reduced by 20 per cent. below the already reduced estimates for the previous year. In this way the figure of 427,000*l.* spent in 1920–21 came down to 339,000*l.* in the following year and in the year now under notice has been only 312,000*l.*, while the estimate of the programme for the current year is reduced to 281,000*l.*, which approximately is no more than half the original estimate for 1921–22. The adjustments to which these figures are subject leave their general effect unaltered.

It can well be believed, as remarked in the report of the Advisory Council, that unless increased provision can be made in future years, the Department will be unable to carry out effectively the duties of co-ordination laid on it by the Government in the interests of economy, and that any further reduction would entail the abandonment of complete schemes of work. To some extent the Department's close relations with the public may place it at the receipt of some of the generous custom that is bestowed from time to time by generous benefactors. In some of the measures that the Department has actually in contemplation when its means allow there are, as will be seen in the account of the Advisory Council's report, several in which a private benefactor may find a congenial opportunity for permanently promoting the public good. For such a disposition the Department's constitution, by which its policy and proceedings are guided largely by the best instructed opinion of the competent public, should make it a particularly attractive body to employ in dedicating means to the public benefit. To such a body the donor of a capital sum could entrust the amount required for some costly but desirable structure with an unusual confidence that whatever conditions, such as maintenance, he might attach to his gift would be observed in the spirit as well as to the letter.

In the nature of things, however, such benefactions are windfalls, and the financial provisions for a department cannot safely be allowed to rest on them. The Research Department cannot be one of the numerous branches of Government, like, for instance, police, that may be most satisfactory when their activities and the means they require are smallest. Its business is both to help industry and to peg out claims for it in the necessitous present, and to show how further to mobilise national and perhaps Imperial resources in the critical period that lies ahead. Straightened though the State's resources may be, these are objects for which adequate provision cannot safely be neglected or postponed. The economical motives that have prompted the large reduction of the Department's expenditure, when admittedly a substantial increase was required, cannot be questioned. But among those who know the extent to which industry stands to gain by the results of orderly scientific and industrial research, and who realise how much the Department has already done to systematise research in this country, and how much more it could do if it were able to carry out the moderate programmes that it has outlined and has for the present to postpone, the economy that has been effected at its expense must appear an unwarrantable extravagance. It is compromising valuable prospects at an epoch at which they have more than ordinary value for the sake of saving a sum that, practically insensible in the aggregate of the national budget, would be of inestimable and permanent value for the purposes of the research programme that is now being held up.

(To be continued.)

SOME TESTS OF AN AIR-EJECTOR PUMPING VISCOUS HUMUS.

By R. C. S. Walters, B.Sc., Assoc.M.Inst.C.E., and V. G. Pickering.

The following tests were carried out on an air-ejector plant, Fig. 1, for pumping viscous humus from humus tanks recently installed at the Cheltenham Corporation Sewage Works. The object of the tests was to ascertain, approximately, under ordinary working conditions:—

(1) The work required to lift humus compared with that required to lift water.

(2) The efficiency of the ejector, making the assumption that the pipe line friction was the same as with clear water.

(3) The modification of the coefficient of pipe line friction required for such a sludge as humus assuming constant efficiency of the ejector.

(4) The effect of pressure upon the total power absorbed by friction and viscosity in the ejector and pipe line.

Conditions of Tests.—An air receiver of 45 cub. ft. of air was charged up to a pressure of about 40 lb. per square inch. The compressor was shut off and the air put into communication by a valve, as required, with the ejector which had a pressure gauge graduated into large 5-lb. divisions which could be, with fair accuracy, subdivided into ½-lb. divisions. The quantity of water was gauged by a levelling staff, as it was found that the ejector did not always fill up to the nominal 50 gallons. The times were read by an ordinary second hand of a watch from the fall of the balance weight to the rise, *i.e.*, the actual time the air from air-delivery pipe was in connection with the ejector.

The thick viscous humus pumped, was the suspended matter in the effluent (about 1,500,000 gallons per day) from filter beds after settling in deep humus tanks of capacity of 120,000 gallons for three or four days.

The indicated horse-power supplied to the ejector was obtained from the drop in pressure of the 45 cub. ft. of air in the time in question, and from the published tables of the work required for compressing air.

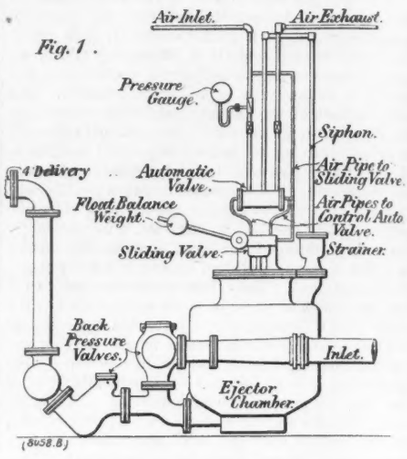
The water horse-power was obtained from the observed weights of water lifted, the heights and the times, or

$$w\,t\,h\,/\,33{,}000 + w\,t\,/\,33{,}000 \times (0{\cdot}011\ lv^2\,/\,2\ \text{gm.}$$

where w denotes the weight raised in the time t, and h the head, whilst l denotes the length of the pipe, v the velocity of flow, and m the hydraulic radius.

From the curves in Fig. 2, it seems that the ratio of the work required to lift humus to water is 15 to 10 (the work done varying directly as the efficiencies plotted), *i.e.*, the work required to lift humus is about half as much again as that required to lift water. Moreover the times of pumping for the same pressures differ in this proportion. Although many of the values are erratic there appears to be some semblance to a law, and it is thought that such variation may be attributed to the varying consistency of the humus.

It is demonstrated that in pumping water the efficiency of the ejector alone was in the neighbourhood of 20 per cent., and thus comparable to that of the ordinary deep well air-lift, which seems quite reasonable; thus from 53 observations the mean efficiencies for pumping water are 20 per cent. and 22 per cent., but the mean efficiency pumping humus is, in the assumptions made, only 15 per cent. and 17 per cent. respectively. Assuming that the ejector is equally efficient when pumping either humus or water, and this may not be an unreasonable assumption, then, the difference must be attributed to the effect of viscosity of the humus passing through



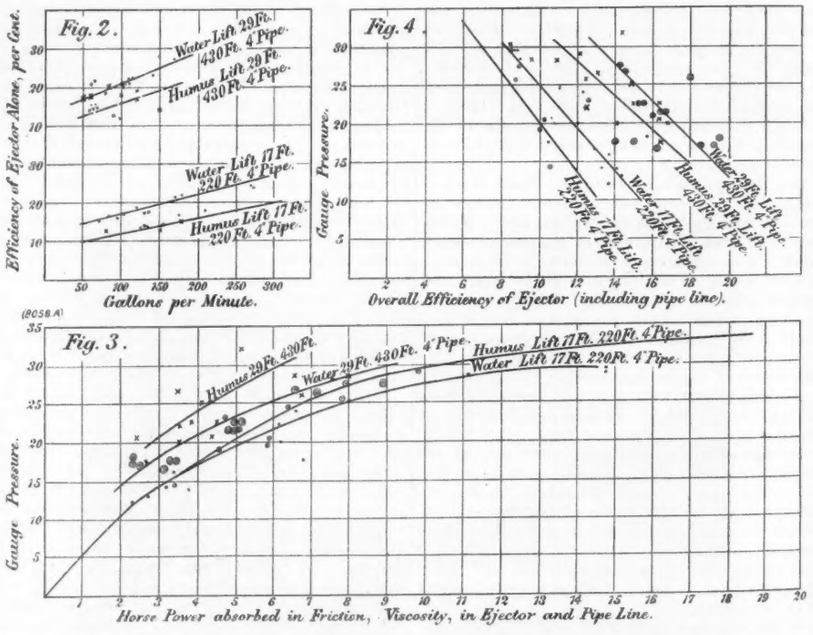


Fig. 2.
Water Lift 29 Ft. 430 Ft. 4 Pipe.
Humus Lift 29 Ft. 430 Ft. 4 Pipe.
Water Lift 17 Ft. 220 Ft. 4 Pipe.
Humus Lift 17 Ft. 220 Ft. 4 Pipe.
Efficiency of Ejector Alone, per Cent.
Gallons per Minute.
Fig. 4.
Water 29 Ft. Lift 430 Ft. 4 Pipe.
Humus 29 Ft. Lift 430 Ft. 4 Pipe.
Water 17 Ft. Lift 220 Ft. 4 Pipe.
Humus 17 Ft. Lift 220 Ft. 4 Pipe.
Gauge Pressure.
Overall Efficiency of Ejector (including pipe line).
(8058.A)
Fig. 3.
Humus 29 Ft. 430 Ft.
Water 29 Ft. 430 Ft. 4 Pipe.
Humus Lift 17 Ft. 220 Ft. 4 Pipe.
Water Lift 17 Ft. 220 Ft. 4 Pipe.
Gauge Pressure.
Horse Power absorbed in Friction, Viscosity, in Ejector and Pipe Line.

CRUDE OIL MOTOR LOCOMOTIVE.

CONSTRUCTED BY AKTIEBOLAGET-JÖNKÖPINGS MOTORFABRIK, JÖNKÖPING, SWEDEN.

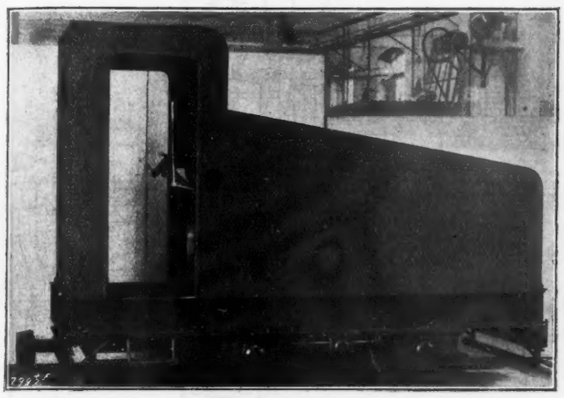


FIG. 1.

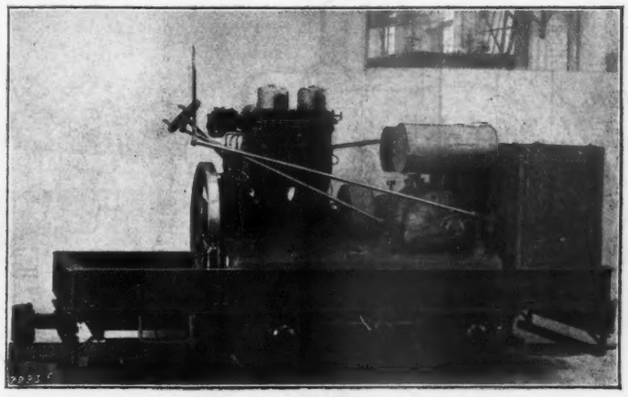


FIG. 2.

Fig. 3.

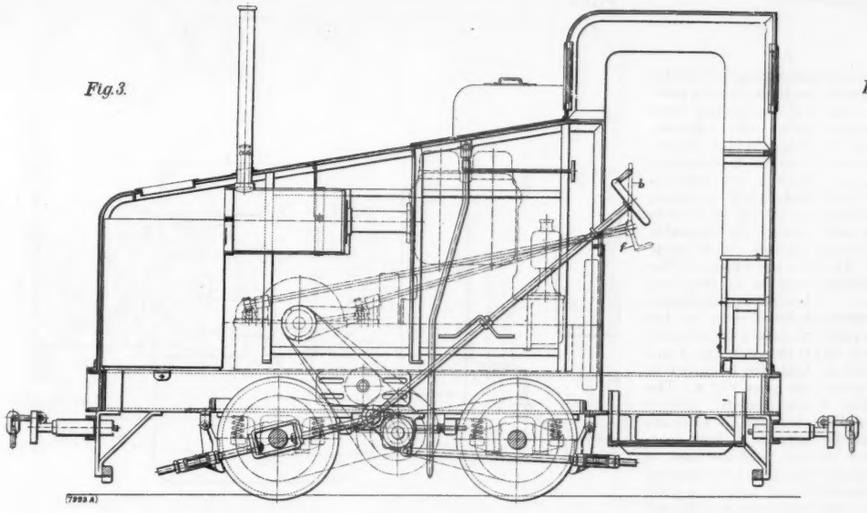


Fig. 5.

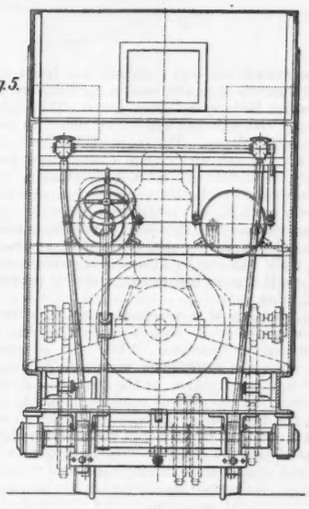
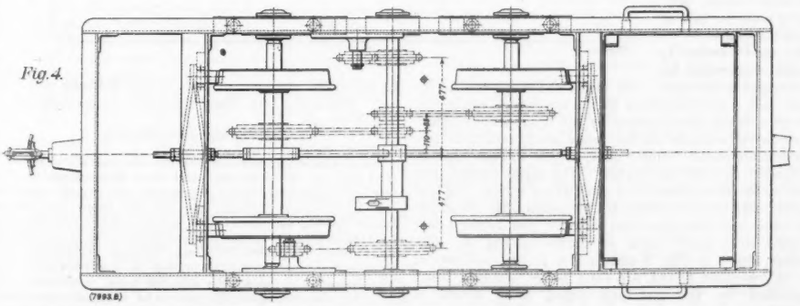


Fig. 4.



the pipe, in which case the pipe line coefficient in the formula given above should be increased by 50 per cent., or to about 0·015 to cover this effect.

If the ejector and pipe line are considered as one unit, several practical points of this particular plant are brought out in a general way, namely :—

(*a*) That the actual friction horse-power—that is, the indicated horse-power less theoretical horse-power ($w\,t\,h$/33,000) to raise the charge in the time—appears to increase uniformly up to about 25 lb. per square inch, after which it increases very rapidly with rise of pressure (Fig. 3).

(*b*) That for the shorter length of pipe and smaller lift more horse-power seems to be consumed between the pressures 20 lb. to 30 lb. per square inch, than with a larger length of pipe with clean water, which may be due to air blowing through the thin liquid more than the humus (Fig. 3).

(*c*) That the overall efficiency increases, approximately, inversely as the pressure (Fig. 4).

(*d*) The efficiency when pumping humus is less than when pumping water (Fig. 4).

(*e*) That the efficiency is appreciably greater for greater lifts at all pressures when pumping either water or humus (Fig. 4).

It will be noted that the above figures relate only to the ejector and pipe line and do not include the engine and air compressor. Taking these into consideration with the time of filling the ejector, the most convenient pressure for working either water or humus is about 20 lb. per square inch for the 29-ft. lift, and the plant, although of low theoretical efficiency, is found very satisfactory for the purpose for which it has been installed. Thanks are due to Mr. A. Honeysett, A.M.Inst.C.E., for much help in the preparation of this paper.

CRUDE OIL MOTOR LOCOMOTIVE.

THE internal-combustion motor locomotive amply proved its ability to handle effectively certain classes of special traffic during the war. Though no really practical results have followed attempts to apply this form of motive power to large units, in small sizes very serviceable machines are now available. Over the small steam engine they present various advantages which are often strong recommendations in their favour when shunting about yards and works is involved. These points include the absence of smoke and sparks, cinders, risk of fire, &c., while the fact that they are very quickly available when needed and can be used for an isolated job, for which it would be a nuisance to get a steam engine ready, is a distinct advantage.

In the illustrations annexed we give in Figs. 1 and 2 two views of a crude oil motor locomotive of the Aktiebolaget-Jönköpings Motorfabrik, of Jönköping, Sweden, whose representatives in this country are Messrs. Dow and Wilson, of 32, Fenchurch-street, London, E.C. Figs. 3, 4 and 5 give, respectively, a side elevation, plan and section through cab. On page 554 details of the crude oil engine are shown in Figs. 6, 7 and 8, on page 554, while the transmission is illustrated in Figs. 9 to 12, on page 555.

The locomotive, known as the "June," is four-wheeled, both axles being chain-driven. The side members of the main frame are of heavy rolled steel channels with horn blocks bolted to the lower flange.

ENGINE FOR CRUDE OIL MOTOR LOCOMOTIVE.

CONSTRUCTED BY AKTIEBOLAGET-JÖNKÖPINGS MOTORFABRIK, JÖNKÖPING, SWEDEN.

Fig. 6.

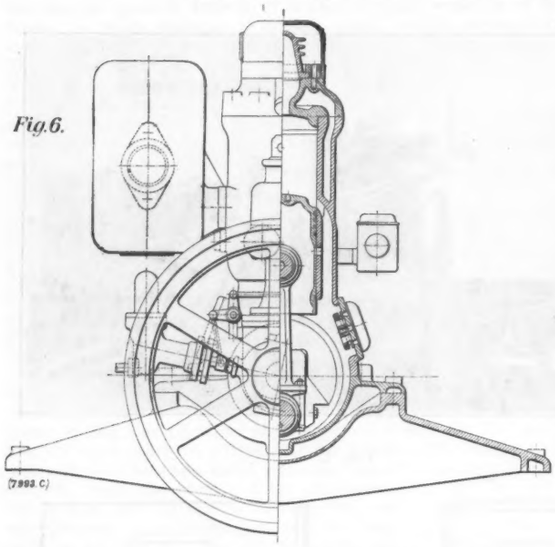


Fig. 7.

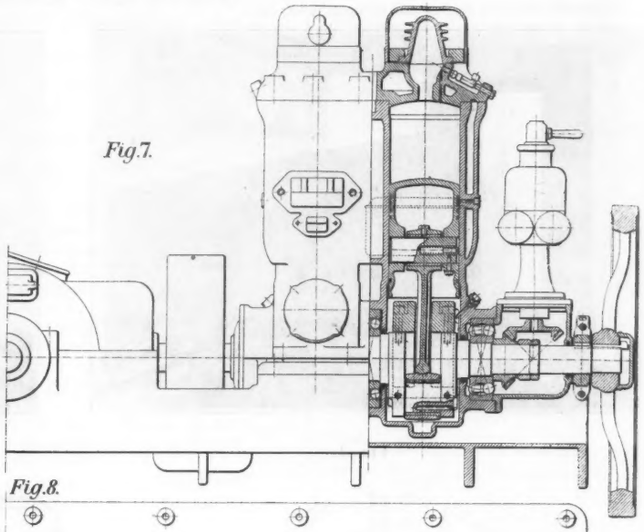
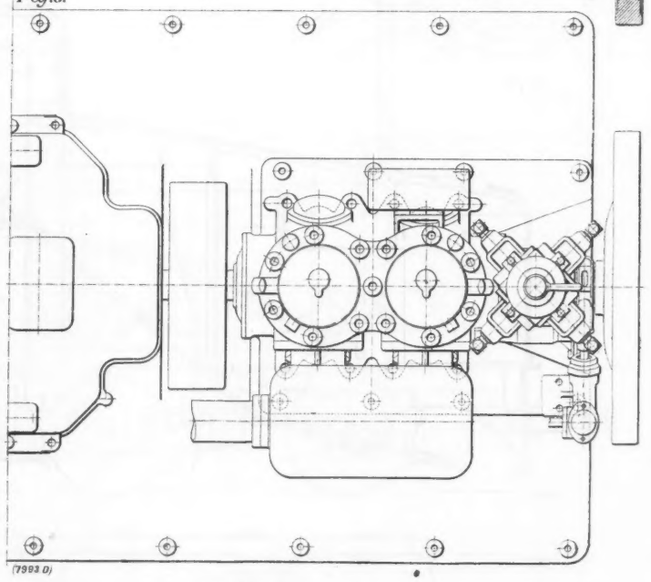


Fig. 8.



The headstocks are also channels, and below them are placed channels of smaller section on which are mounted the central buffers and draw gears. The engine bedplate and the gear-box are bolted direct to the upper flanges of the frame. The engine is well seen in Fig. 2, in which the cab and engine casing have been temporarily removed. It is a two-cylinder, two-cycle machine with crank-case compression, provided with hot bulb ignition, and centrifugal governor controlling the fuel pump. The flywheel is used for starting, and is accessible from the cab, protection, however, being given while running by means of a guard cover. The crank-shaft runs in ball bearings and is provided with forced lubrication.

The question of a practical solution of the transmission problem is always interesting in internal-combustion locomotives. While not so difficult in small units the mechanism must still be practical in design and construction, or the machine will not prove a success. In the present machine, referring to Figs. 9 to 11, the direction of running is controlled by the rod *a*, Fig. 10, operated by rack and pinion from the cab, by the hand crank *b* (Fig. 3). By turning this crank to the right or left, thus moving the rod *a* to one side or the other, one of two main clutches on the transmission shaft is engaged, according to the direction of running required, or the gear can be placed in neutral. The drive is thus from the engine shaft through the bevel gears shown in Fig. 9, by way of one or other of the clutches to the shaft on which are two chain sprockets *c* and *d*. These transmit the drive by chain to corresponding gears on an intermediate shaft, whence chain drives transmit the power to the axles. The drive from the sprockets *c* and *d* gives two speeds, the ratios of the two sets of gears on the transmission and intermediate shafts being different and suitable for speeds of 6·8 m.p.h. and 3·1 m.p.h., respectively. Either speed may be used in connection with the forward or reverse main clutches, by moving over to one side or the other the rod *e* which is controlled by the handle *f* in the cab (see Fig. 3). The rod *e*, worked by rack and pinion, causes one or the other of two dog clutches to engage, as will be clear from Fig. 10. It will be noticed that the transmission shaft is carried in ball bearings, and that the main clutch drums are fitted in like manner (Fig. 9).

A simple locking device is introduced so that speeds cannot be changed without throwing the main clutches into neutral. This device consists of a collar on the rod *e* which fouls a bent lever passing under the clutches (Fig. 11), where it is pivoted on lugs on the casing, and extending up till it fouls a bobbin shaped cam on the rod *a*. When the latter is in such a position that either main clutch is engaged the cam depresses the end of the lever, lifting the opposite end so that it fouls the collar on *e* and the latter cannot be moved. If the main clutches are in neutral the waist of the cam on *a* allows the bent lever to rise so that its opposite end clears the collar on *e* and the speeds can then be changed.

The intermediate shaft is carried in bearings the position of which is adjustable so that the slack of the driving chains to the axles can be regulated. This adjustment is made by horizontal screws passing through lugs fixed under the solebars. Slack in the chains from the transmission shaft to the intermediate shaft is taken up by idler sprockets carried by movable brackets fixed inside the main frame. The position of one such bracket with its slotted holes allowing for the necessary adjustment, is shown in Fig. 3 and both are indicated in the plan Fig. 4. The intermediate driving shaft and the axles are carried in ball bearings. In the case of the latter, the bearing forms part of a yoke which extends beyond the horn blocks, providing seats for helical bearing springs.

A hand brake is furnished operated by hand wheel in the cab. The brake rod is screwed at its lower end, and is furnished with a nut which works the arm of a brake shaft carried by the intermediate shaft. From two short arms on the brake shaft pull rods run fore and aft to the hanger gear, which in each case is suspended outside the axles. The large rectangular tank at the front end is for circulating water. Of the two circular tanks over the transmission unit one is the fuel tank and the other the silencer, the latter being coupled to a short stack as shown in Fig. 3. The casings shown in Fig. 3 and in Fig. 5, just in front of the cab weather board, are sand boxes, sanding being controlled by the rod and small hand wheel in the cab.

Two sizes of this type of locomotive are built fitted respectively with engines developing 20 b.h.p. and 30 b.h.p. In the former case the engine speed is 650 r.p.m., and the machine weighs about 8,800 lb. On a good track this engine can handle trains of about 30 tons, a single speed being provided of 6·8 m.p.h. The larger machine weighs about 10,770 lb., and its engine has a speed of 550 r.p.m. This locomotive under similar conditions can take a train of about 48 tons gross weight. Two speeds are provided as described in the foregoing, one being the normal of 6·8 m.p.h., and the other a slow speed of 3·1.

The cost of working such machines is said to be about 42 per cent. below that of the cost of running a petrol locomotive, and they have been adopted for brickworks, quarries and mines, lumber work and numerous other conditions, working even over considerable distances. The normal gauges to which the engines are built range between 600 mm. and 890 mm., but they can also be constructed to wider gauges.

DENMARK'S IMPORTS OF COAL.—Denmark's imports of coal are on the increase, and with the exception of a negligible quantity from Germany, the whole quantity was from Great Britain, the imports from the United States having apparently ceased altogether. During the first eight months of the present year, Danish coal import amounted to 1,989,238 tons, against 1,606,659 tons during the corresponding period of the previous year. The imports of coke were 374,090 tons, against 419,060 tons for the corresponding period of 1922, and the figures for briquettes were respectively 9,864 tons and 14,704 tons. The imports from Germany during the first eight months of the present year amounted to 24,906 tons against 4,626 tons for the corresponding period of the preceding year.

AGRICULTURAL MACHINERY IN RUSSIA.—The Danish Delegation in Russia states that attempts have been made in Russia to take up manufacture within the country of agricultural implements and machinery, but for several reasons, more especially shortage of capital, this has not met with the success anticipated. For the present year production was expected to reach a value of about 20,000,000 gold roubles, but has only amounted to 7,900,000 gold roubles, which, however, is 40 per cent. in excess of the preceding year's output. Of this output 6,700,000 gold roubles worth of goods were sold. The selling conditions have proved difficult, the price averaging some 80 per cent. above the pre-war price. The price of grain, however, has also risen, but not in proportion to that of agricultural machinery and implements.

CRUDE OIL MOTOR LOCOMOTIVE.

CONSTRUCTED BY AKTIEBOLAGET-JÖNKÖPINGS MOTORFABRIK, JÖNKÖPING, SWEDEN.

(*For Description, see Page* 553.)

Fig. 9.

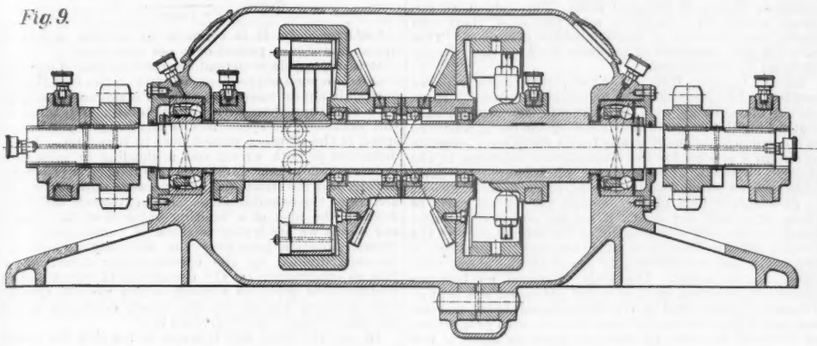


Fig. 11.

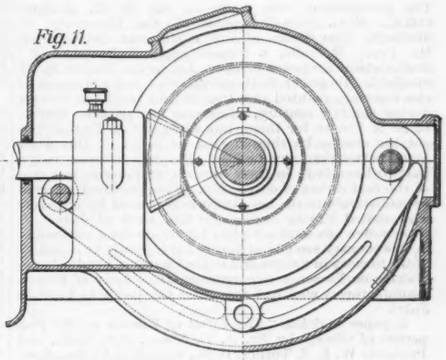


Fig. 10.

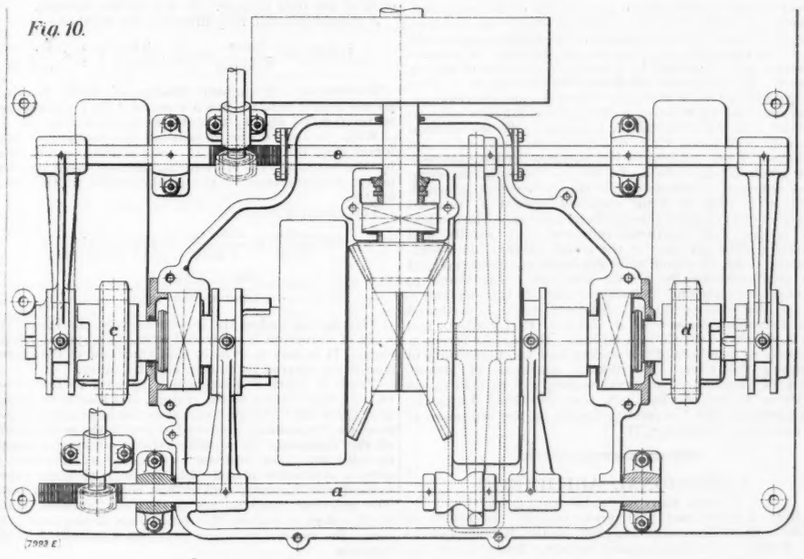
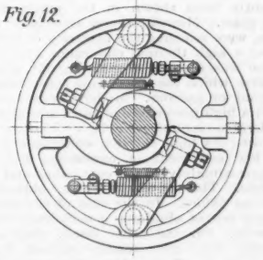


Fig. 12.



THE DARIMONT PRIMARY CELL.

A NEW form of primary cell, the properties of which appear to render it very suitable for operating telegraphs, telephones, railway-track signalling apparatus, &c., as well as for supplying filament current for the thermionic valves used in wireless receiving apparatus, has recently been placed upon the market by Darimont Electric Batteries, Limited, 536, Salisbury House, London, E.C. 2. The cell, which is the invention of a Belgian engineer, Mr. L. Darimont, and therefore bears his name, is of the two-fluid type, the elements used being zinc and carbon.

The zinc plate is enclosed in a porous pot and surrounded by a paste, or viscous emulsion, made up of sodium chloride, calcium carbonate and other materials, which always remain chemically neutral. This feature, the makers claim, practically eliminates local action and also renders the corrosion of the zinc extremely uniform while the cell is in use. The carbon plates are immersed in a liquid depolariser consisting mainly of ferric chloride, which surrounds the porous pot containing the zinc, and both elements are placed in a rectangular glass container. The space between the porous pot and the glass container at the top of the cell is closed by a special sealing compound which holds the carbon plates and the porous pot in position; a small tube passing through the sealing compound is provided to enable the depolarising fluid to be poured in or drained off. The top of the porous pot is closed by a loose cover having a hole in the centre through which passes a lead terminal strip connected with the zinc plate.

The main advantage of the two-fluid type of cell over the single-fluid type is that the liquid depolariser used in the former is generally more effective than the solid depolariser employed with the latter, and consequently a heavier and more constant current can be obtained. Most of the common types of two-fluid cells, however, suffer from the fact that diffusion between the two liquids takes place comparatively rapidly, so that the cell soon becomes ineffective. Serious corrosion of the zinc may also take place from this cause, even on open circuit. In the Darimont cell, this difficulty has been overcome by the use of two fluids for the electrolyte and depolariser, respectively, which, on contact in the pores of the porous pot, form a semi-permeable membrane which practically prevents diffusion while still maintaining electrical continuity. Consequently there is very little variation in the internal resistance, and the cells can be used to give small currents continuously as well as to give heavier currents intermittently over long periods.

The cell, which is made in five different sizes, has an electromotive force on open circuit of about 1·6 volts, and the five sizes have capacities ranging from 12½ ampere-hours to 150 ampere-hours, when discharged down to an E.M.F. of 1 volt. As an example of the characteristics of the cells we may mention that a curve obtained at the National Physical Laboratory shows that a cell rated at 75 ampere-hours capacity discharged at the rate of 0·75 ampere for 2 hours daily, maintained a steady voltage on the closed circuit of 1·2 volts for 45 days, the voltage then gradually dropping to 1 volt over a further period of three days. The actual output in this test was 85·5 ampere hours or 92·3 watt hours, in discharging down to 1 volt. In another test, the zinc consumed per ampere hour was 1·25 grammes, and as the theoretical figure is 1·213 grammes it is evident that the local action is extremely small.

When exhausted, the cell can be recharged by renewing the depolariser and paste electrolyte, together with the zinc, the quantities of these three constituents being proportioned so that they all require renewing at the same time. In addition to the advantages already mentioned, the makers claim that the cell gives off no objectionable fumes in working, that the chemicals used are not in any way dangerous to handle, and that no crystallisation takes place in the cell. The zinc chloride formed when the cell is in action remains in solution and the ferric chloride is reduced. Finally we may mention that the cells are manufactured entirely in this country.

THE LATE DR. C. P. STEINMETZ.

CHARLES PROTEUS STEINMETZ, one of the greatest electrical research workers of our day, died suddenly at his home in Schenectady, New York, on Friday last. He was born in Breslau on April 9, 1865, and studied mathematics and physics in the universities of Breslau, Berlin and Zurich. After settling in America and pursuing further his electrical investigations, he was appointed consulting engineer to the General Electric Company of America, at the early age of twenty-eight years. His research work and original mathematical investigations were made the basis of the valuable series of books which he wrote. His general works, such as the "Theory and Calculation of Alternating Current Phenomena," and "Theoretical Elements of Electrical Engineering," are well known to all electrical students. In 1902 he accepted the professorship of electrophysics in Union University, New York, but still continued his work in association with the General Electric Company.

In addition to showing the progress of knowledge of electrical phenomena through his writings, he contributed freely to the various American scientific institutions, and these addresses were looked forward to as providing a valuable gauge of future possibilities. In this phase of his activity he possessed the faculty, rare among original scientific thinkers, of being able to show the significance of the work he was engaged upon in the immediate and future practical development of the electrical industry. Not only did he give a lead to his profession in the United States but also to the general populace as potential users of electricity. He was a pioneer and a man of many eccentricities, but he could always frame a message for the public in terms they could understand. Through that ability he contributed largely to the extended use of electricity in America.

The union University gave him the degree of Ph.D., while Harvard presented him with the M.A. *honoris causa*. He was a past president of the American Institution of Electrical Engineers, and of the Illuminating Engineering Society and, despite the many activities of his professional life, he still found time to play a valuable part in the educational affairs and local administration of Schenectady.

THE SOCIETY OF GLASS TECHNOLOGY.

THE first meeting of the Society of Glass Technology for the session 1923–24 was held in Sheffield on October 17, the president, Professor W. E. S. Turner, D.Sc., in the chair. The initial formal business included the presentation of "Frank Wood" medals to Mr. A. R. Sheen, B.Sc.Tech., and Mr. F. Winks, B.Sc.Tech. The presentation was made by Sir W. H. Hadow, C.B.E., M.A., Vice-Chancellor of the University of Sheffield. The design of this medal was the work of Mr. Percy Metcalfe, a former pupil of Professor W. Rothenstein, Professor of Civic Art in the University of Sheffield. Professor Rothenstein, who was welcomed to the meeting, pointed out that it had been the custom during the last century, when new medals were struck, to go to France for them, but whenever an Englishman got his chance he showed that he could do this work much better than anyone else. People would not realise that to have faith in their own contemporaries was one of the first duties of citizenship. The President referred appreciatively to the hospitality experienced by members who visited France during the first week of July. It was resolved to send a cordial invitation for a conference in this country some time during 1924, jointly to members of the Society in France and to the Chambre Syndicale des Maîtres de Verreries (the representative body of French manufacturers who had welcomed the party to Paris in July).

A paper entitled "*The Effect of Titania on the Properties of Glass*," by Mr. A. R. Sheen, B.Sc.Tech., and Professor W. E. S. Turner, D.Sc., was given by Mr. Sheen and illustrated by lantern slides. In presenting this paper Mr. Sheen remarked that a great deal of interest had recently been shown in the production of heat-resisting glass. Manufacturers, especially of scientific glassware, were realising the necessity of making a glass which had a high thermal endurance and which at the same time was capable of resisting the attack of substances with which the glass came into contact, whether solid, liquid or gaseous. Modern heat-resisting glasses contained a high percentage of silica and also boric oxide in considerable amount, *e.g.*, the well-known glass pyrex (which owed its high thermal endurance to its exceptionally low coefficient of expansion, 0·0000032) contained approximately 80 per cent. silica and 12 per cent. boric oxide. There were, however, objections to the use of these oxides. In the case of silica the difficulty was merely one of obtaining a sufficiently high melting temperature. On the other hand, glasses containing boric oxide were very readily melted, but here the objection was the effect of the oxide on the durability of the glass. Recent research in the Department of Glass Technology of Sheffield University had shown that as the B_2O_3 content of a glass was increased the durability towards water and acid increased to a maximum, and then as the B_2O_3 content was further increased, the durability fell off rapidly. Boric oxide containing glasses (and of course glasses with high silica content), on account of their acidic nature, were very readily attacked by alkali, *e.g.*, it was quite useless using pyrex ware as an alkali container. What information there was concerning the use of titania in the production of glass seemed to point to the fact that titania glasses were heat resisting, but no experimental data were given. It was with this consideration specially in mind that this piece of work was undertaken. At the outset preliminary tests were made to find out what mixture of silica, titania and soda would give glasses at the highest temperature obtained in glass-melting practice, *e.g.*, temperatures of 1,400 deg. to 1,450 deg. C. It was found impossible to obtain a glass from silica and titania alone at this temperature. Batches were then calculated out on the basis of the glass formula :—

$$6\ SiO_2\ x\ Na_2O\ y\ TiO_2, \text{ where } x + y = 2$$

and it was found that the first six members of the series gave glasses quite readily, *i.e.*, glasses of the approximate molecular compositions :—

(1) 6 SiO_2, 1·9 Na_2O, 0·1 TiO_2,
(2) 6 SiO_2, 1·8 Na_2O, 0·2 TiO_2,
&c. &c. &c.
(6) 6 SiO_2, 1·4 Na_2O, 0·6 TiO_2,

in which the soda was gradually replaced by titania. Above 1·8 mol. TiO_2, *i.e.*, 13 per cent. TiO_2, it was found increasingly difficult to melt the glass and higher temperatures were required. It was found that if these glasses were melted under reducing conditions, their colour varied from light amber to dark brown. Therefore part of the soda content was added as soda nitre, and the melting operation was carried out in crucibles with well-fitting lids. By this means colourless glasses were obtained. There were indications during these melting operations that titania glasses were heat resisting. It was found in many cases that the glass could be removed straight from the furnace and allowed to cool down in the open air without splintering or cracking of the mass of glass occurring. After considering the analysis of these six glasses the first question dealt with was the durability of the titania glasses towards water. It was found on comparing with the corresponding lime and magnesia glasses that the titania glasses were less attacked than the lime glasses, especially in the earlier members of the series. The durabilities of the titania glasses were found to be practically the same as those of the corresponding magnesia glasses. The annealing temperatures were found to be rather less than those of the corresponding lime and magnesia glasses. Next, the important question of thermal expansion was dealt with. It was originally intended to determine this optically by the Fizeau-Pulfrich method, but after discussion it was eventually decided to repeat the melts on a large scale (28-lb. pot), to draw tubing and determine the expansion by the ordinary dilatometer method. The thermal expansions of these titania glasses (only the first four glasses of the series were tested) were only slightly less than those of the corresponding lime glasses. Therefore, if titania glasses are heat resisting, it is certainly not due to their having a low expansion, as is the case with pyrex glass, for example, but the cause must be sought in some other factor, such as tensile strength or elasticity. These glasses possessed good working properties, their viscosity increasing as titania replaced soda. Throughout all the glasses melted in connection with this work there was hardly any evidence of devitrification occurring. This bore out the statement of previous workers that titania hindered devitrification.

Mr. A. Cousen, B.Sc., A.R.C.S., then gave a paper entitled "*The Estimation of Selenium in Glass*." Illustrating his remarks with experiments, Mr. Cousen said that during the course of researches on the use of selenium as a decolourising agent it was found desirable if possible to obtain a process for the estimation of selenium in the glasses obtained. The amount of selenium actually added to the batch was, in general, of an order sufficient to give only 1 part of the element per 42,000 parts of glass, or 0·0024 per cent., if no loss occurred. Since, however, selenium was volatile at the temperature of the furnace (the boiling-point at 1 atmosphere pressure is 680 deg.), values considerably less than the above were likely to be found. The only chemical method for estimating selenium in glass so far published was that of Fränkel, and described by Witt (Sprechsaal, 1914), and this was not quite comparable since it dealt with proportions of selenium at least 10 times as great as those it was desired to estimate. The following modification of the above process was found to give results of fair accuracy. Twenty grammes of finely-powdered glass were dissolved slowly in hydrofluoric acid, and after standing in the cold with the exception of selenium, the products of decomposition were dissolved by pouring into excess of boiling water. The selenium itself was filtered off on a filter pulp pad in a Gooch crucible. From the pad the selenium was removed by treating with a dilute chlorine solution (about one three-hundredth normal). To the filtered solution was added 1 c.c. of 5 per cent. gum arabic and 5 c.c. of ½ per cent. phenyl hydrazine hydrochloride—the whole being made up to 50 c.c. Colloidal selenium was obtained, a yellow colour slowly developing, which was, after half an hour, matched against a standard solution of sodium selenite similarly treated. The method on testing with synthetic mixtures gave results well within 0·0002 per cent. of the actual values, and a commercial glass, for which sufficient selenium had been used to give theoretically 0·0025 per cent., was found to contain actually only 0·0006 per cent. of the element.

To the discussion that followed there contributed the President, Messrs. W. J. Rees, J. H. Davidson, and J. R. Clarke. Mr. Cousen replied. During the forenoon a party of members of the society had an opportunity of visiting the River Don Works, Sheffield, of Messrs. Vickers, Limited. The next meeting will be held in the Lecture Room of the Coal, Gas and Fuel Industrial Department, the University, Leeds, on the afternoon of Wednesday, November 21.

DIMENSIONAL ARITHMETIC.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the article in your issue of September 28, 1923, on Dr. Stroud's system of dealing with dimensional factors. Some years ago you published under my name an article on this subject (ENGINEERING, April 11, 1913, page 501), and my experiences may perhaps be of interest.

My introduction to the system was due to Dr. Stroud and took place over 20 years ago; I have used it and developed it as a teacher for the last 15 years. In my opinion it is the most valuable dodge of its type I have ever met with, and its introduction would add enormously to the value of the present treatment of physical subjects.

The first difficulty I encountered was the objection on the part of physicists to extend "multiplication" to physical quantities. Indeed, Professor Tait, of Edinburgh, states in one of his published letters that such expressions as "feet divided by seconds" are meaningless. Although I should be prepared to advocate the use of dimensional arithmetic in the face of small irregularities in strictly logical methods, there is in fact no need to do so. Dimensional arithmetic is in strict accordance with the rules of the game. We start by defining what we mean by (2×3) as a convenient abbreviation for $(3 + 3)$ or $(2 + 2 + 2)$; but the extension of the symbol to include $(0{\cdot}3 \times 0{\cdot}2)$ and $((-3) \times (-2))$ is a deliberate extension of the meaning of $\times$. The only essential quality of the connection $a \times b = c$ is that an increase of a or b leads to a proportional increase in c.

We are quite at liberty to define (1 ft. × 1 ft.) as meaning in certain cases an area equal to the area of a square with sides 1 ft. in length. Having adopted that definition, we are then ready to deal with the area of a rectangle from the formula—

$$\begin{aligned}\text{Area of rect.} &= l \times b \\ &= \text{say, 2 ft.} \times \text{3 ft.} \\ &= 6\ (\text{ft.} \times \text{ft.}).\end{aligned}$$

The result can be interpreted as meaning "six times the area of a square with sides 1 ft. in length."

The conception of division seems to cause more bother, not because it fails to be logical, but largely because the physicists themselves have almost universally adopted an illogical nomenclature. The crux of the matter is that we must have some way of distinguishing between

(*a*) The distance passed over in unit time;
(*b*) The average speed.

(*a*) is a distance and (*b*) is a speed; the two quantities are entirely distinct; speed is a compound of time and distance, but is neither a time nor a distance.

The difficulty disappears if the word "per" is restricted to mean "divided by" in the extended sense of division.

In this way speed is (distance per time) or in mathematical form—

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}.$$

Unfortunately, it is common to use the definition: Speed is distance passed over per unit time.

It is impossible to defend the introduction of the word "unit" in such expressions, in spite of the fact that the custom is almost universal. Speed is no more connected with *unit* time than with *unit* distance; and, indeed, if this definition of speed means anything it means that speed is the distance passed over in unit time. Such a definition is both wrong and misleading in spite of its universal adoption. Moreover, the danger is of a subtle nature, and the effects are not apparent until the student arrives at the calculus stage. It is extremely difficult to develop the idea of a limiting value if at the back of our minds we are trying to think of "unit time." The Stroud notation gets over the difficulty; speed is a distance divided by the corresponding time; we are free to concentrate on the conception of speed, and our mathematics gives us a result which we can translate into ordinary English by the simple expedient of substituting "per" for "divided by."

In just the same way it seems to me that the conception of density is hidden by defining it as the mass (or weight) per unit volume. It is mass per volume.

A simple example may illustrate the method.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \text{say, } \frac{3\text{ lb.}}{2\text{ in.}^3} = \frac{3}{2} \times \frac{\text{lb.}}{\text{in.}^3}$$

Translation.—A uniform density of 1 (lb. per in.^{3}) means that 1 cub. in. has a mass of 1 lb.; the assumed material has a density of $(\frac{3}{2})$ times this amount.

With regard to the details of the method, I have found that the alteration of units is most surely made by the introduction of reducing factors, each equal to unity, in preference to the method used in the recent article.

For example—

$$360\ \frac{\text{miles}}{(\text{hr.})^2} \times \frac{5280\text{ ft.}}{1\text{ mile}} \times \left(\frac{1\text{ hr.}}{60 \times 60\text{ secs.}}\right)^2$$

$$= \frac{360 \times 5280}{3600 \times 3600}\ \frac{\text{ft.}}{\text{sec.}^2}.$$

This layout makes the factors easy to check, and the work of reduction is separated from the physical conceptions. It is easy to explain that the value of the expression is not altered by multiplying by unity.

There is another detail which appears to me to add to the completeness of the system, and that is to arrange that the word "radian" can alone be inserted or deleted from the expressions in accordance with the requirements of the meaning. If possible, then, no symbol should be used for "the number" of so-and-so. As soon as such a symbol is introduced, we have to some extent limited our formula, and it has ceased to be general. The practical disadvantage is that the omission of this symbol does not affect the dimensions of the result, and hence the system no longer provides a full check on the formula.

In torsion, for example, we get a formula of the form—

$$\theta = \frac{T \times l}{C \times I}.$$

The result will appear without units and hence the word radian may be inserted in accordance with the sense of the formula.

Derived from this formula we can obtain a formula for the deflection of a helical spring.

$$\delta = \frac{W \times \frac{D}{2} \times l \times \frac{D}{2}}{C \times I}$$

The length l can be expressed as (length per coil) (quantity of coils).

In practice the "quantity of coils" is expressed as turns or revolutions; but there is no reason why it should not be expressed in radians or in degrees or any other unit of coiling. Hence, it is wrong to limit our formula to the use of "turns." If we retain n as the symbol for "quantity of coils," we can proceed in the following way :—

$$l = \frac{\pi D}{\text{turn}} \times n.$$

The formula is still general, but is convenient for the insertion of n in "turns."

The complete formula is then—

$$\delta = \frac{W \times \frac{D}{2} \times \frac{D}{2} \times \frac{\pi D}{\text{turn}} \times n}{C \times I}$$

$$= \frac{W \times D^2 \times \pi D \times n}{4 \times C \times \frac{\pi d^4}{32}} \times \frac{1}{\text{turn}}$$

$$= \frac{\delta W D^3 n}{C d^4} \times \frac{1}{\text{turn}}.$$

If we care to express n in degrees, our formula is still correct; if we express it in turns, our words cancel out; if we omit it inadvertently, our words do not cancel and remind us of the slip. The real source of the awkward-

ness is that our language fails us and we have no recognised expression for such conceptions as a quantity of coils.

Although the use of N as the "number of coils" may be advisable with certain students, there always is a danger of sliding back into the old ditch and allowing the use of S as the "number of feet" and *t* as the "number of seconds." I am inclined to advocate the strict exclusion of such symbols.

In applying the method to simple proportion in school work, the difficulties in this direction are increased because we have no supply of recognised words. We are apt to refer to the "number of men" employed in mowing a field, and thereby we cut out our dimensions. The number of men is a numerical factor only, and we cannot say that the "number of men" is "3 men."

I suggest, therefore, that in such cases general words should be used.

For example—

$$\text{Time} = \frac{\text{Quantity or work}}{\text{Quantity of workers}}$$

$$= \text{say, } \frac{60 \text{ acres}}{6 \text{ men}} \times \frac{(10 \times 20) \text{ man-days}}{100 \text{ acres}}$$

$$= 20 \text{ days}$$

In the first step, acre is the unit of the work; then acre is converted to man-days in accordance with the information supplied. I am not prepared to say when such treatment can be used in schools, but I have no doubt in my own mind as to when I should introduce it if I were a teacher in a school. I should introduce it as soon as simple algebraic notation had been dealt with.

May I be allowed to suggest that the prominence given in your recent article to the various systems of measuring force, and mass may give a wrong impression to the casual reader? Such explanations are interesting, but in teaching should be avoided in the early stages.

At a certain stage a boy learns that "acceleration is proportional to the force causing it." He knows that if a force of 6 lb. causes an acceleration of 8 ft. per sec.^{2}, then. 12 lb. will cause (8 ft. per sec.^{2} $\times$ $\frac{12}{6}$) in the same body.

He writes this as—

$$8 \text{ ft. per sec.}^2 \times \frac{12 \text{ lb. wt.}}{6 \text{ lb. wt.}}$$

or

$$\frac{8 \text{ ft. per sec.}^2}{6 \text{ lb. wt.}} \times 12 \text{ lb. wt.}$$

In the latter form he can work out the "rate" once and for all, and thus deal with any force which may be applied to the body. He recognizes the "rate" as a property of the body just as he recognizes "price" as a property of a commodity.

In the form $\frac{g}{} \times \frac{\text{lb. wt.}}{\text{ft. per sec.}^2}$ he gets the idea of measuring inertia or mass, and he sees that this body requires 6 lb. wt. to produce 8 ft. per sec.^{2} and from this information he can deal with other forces and accelerations.

Once these ideas have sunk in, but not till then, it is easy to explain that a body "weighing 2 lb." will move with an acceleration of 32·2 ft. per sec.^{2} under the action of a force of 2 lb. wt.

To give such a body an acceleration of 14 ft. per sec.^{2} will require a force of

$$2 \text{ lb. wt.} \times \frac{14 \text{ ft. per sec.}^2}{32 \cdot 2 \text{ ft. per sec.}^2}$$

or

$$\frac{2 \text{ lb. wt.}}{32 \cdot 2 \text{ ft. per sec.}^2} \times 14 \text{ ft. per sec.}^2$$

I find this procedure clearer and simpler than starting with *g*, and I prefer to treat mass as a rate in the first place, rather than introduce the word lb.-mass and then reduce it to some other unit quite unfamiliar to the normal activities of students. At a later stage, the alternative methods are excellent as practice, but are apt to be confusing at the start.

Although I have had no opportunity of an extended test, it seems to me that the Stroud system could be used to give life to some of the elementary algebraic manipulations.

For example—

If $12\,d = s$, express $13\,d + 3\,s + 2\,d$ in terms of s.

Find the sum of $(16\,s + 3\,d) - (5\,s + d) + (3\,s - d)$.

Such examples are purely algebraic, until *s* and *d* are translated as "shilling" and "penny" respectively.

The notation is very helpful in devising shortcuts for dealing with special cases, *e.g.*,

$$\frac{l}{960} = \frac{1 + \frac{1}{24}}{1{,}000}\, l = 0 \cdot 001\, l + 0 \cdot 01\, d,$$

where $l = 240\,d$.

Hence, 5,000 articles at 1¼ pence each will cost—

$$5{,}000\ (0 \cdot 001\, l + 0 \cdot 01\, d) = 5l.\ 4s.\ 2d.$$

My personal experience of the system has been that the more I have used it the more advantages I have found, both as an aid in manipulation and as an assistance in teaching. Beyond the points mentioned above, I have so far discovered no disadvantages, and it is hardly fair to blame the method with the shortcomings of the language. In physics, where a sufficient vocabulary has been invented, the method stands supreme. It is nevertheless an astounding fact that its adoption is the rare exception and not the general rule.

S. H. Stelfox.

October 21, 1923.

THE VALUE OF PATENTS.

To the Editor of Engineering.

Sir,—I note with interest your remarks in a leading article of this week's issue of your journal, *re* Sir John Dewrance's presidential address.

Perhaps it would be interesting to notice that on the front of your journal cover alone appear the names of at least eight firms who advertise either patented articles or work following a patented process. Quite a number of the other names are, I believe, of those who either have or do now manufacture patents, although it might not be so specified in the advertisements. Many other firms manufacture not one, but many, patented articles, the patents being the property of employees or independent engineers. A patent is not needed for a long period. It is useful to commence with; it forms a foundation on which to consolidate valuable manufacture. Then afterwards the patent can lapse, because a more powerful protection is found in the advance of a capable production rather than in a patent monopoly. A patent is valueless without the capacity of a system of production, backed by a progressive organisation, to market an article which will hold, even if it does not defy, competition. I saw abundant evidence of this, during and after the war. These are fierce days. The struggle for existence becomes keener and keener. The inventor is urged on by the almost cruel spur of a relentless necessity. As a young man I cannot pass judgment upon the remarks of Sir J. Dewrance, but I am utterly opposed to many of them.

Yours, &c.,

"Inventor."

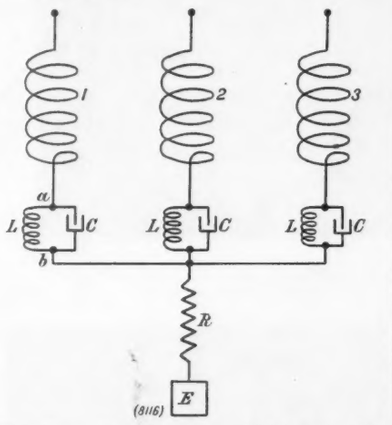
Bath, October 29, 1923.

"A METHOD OF IMPROVING THE WAVE-SHAPE OF ALTERNATORS."

To the Editor of Engineering.

Sir,—In their recent paper before the British Association, entitled "A Method of Improving the Wave-Shape of Alternators," Professor Marchant and Mr. Turney (page 444 *ante*) described an arrangement consisting of a condenser and reactance shunted across the line, the condenser and reactance being related in well-known manner for producing resonance.

A brief description of an harmonic filter which is being successfully used by the British Thomson-Houston Company, for the same purpose, may be of interest. This was referred to by Mr. Jack in the discussion on the above paper. He spoke extempore, however, and the localities he mentioned were not actually where the device had been used.



When the matter was first investigated, the machine concerned was a 550-k.v.a., three-phase, 3,300-volt 50-cycle generator, run with neutral earthed through the usual resistance, and interference with telephones was experienced. This was traced to 35th and 37th harmonics in the voltage wave, resulting from a design feature which has been corrected in later machines. Trials were made with various forms of harmonic filters. One of the circuits tried was that first described by Albert Campbell and applied by him to the exact measurement of frequency. In this circuit a combination of mutual inductance and capacity was used, their product being adjusted to correspond to the frequency. The trial showed that the adjustment could be made sufficiently delicate to cut out either the 35th or the 37th separately and completely, leaving the other harmonic. The arrangement was not adopted, however, as it involved the use of a condenser suitable for full-phase volts.

The scheme finally used consisted in placing at the neutral point in each phase, an air-cored inductance of low value and a condenser connected in parallel, the circuit being tuned to the mean of the two harmonic frequencies. This formed a so-called "rejector" circuit, which allowed the 50-cycle load current to pass freely, but interposed a high impedance in the path of the objectionable harmonics.

In the figure 1, 2 and 3 are the phase windings of the machine, L and C the inductance coils and condensers forming the filter, and R the usual earthing resistance.

It will be noted in this arrangement that, firstly, the condensers are not required to withstand the full 50-cycle line voltage, but only the smaller voltage of the harmonic, and secondly, the whole apparatus is normally at earth potential. The effectiveness of such an arrangement depends, of course, primarily upon the extent to which the effective resistances of coil and condenser at the harmonic frequency can be reduced. The resistance offered to the harmonic current between the filter terminals *a* and *b* is closely equal to $\frac{L}{C\,R}$ ohms, where R is the sum of the resistance of coil and condenser.

The above-described arrangement, which is in successful use, is a "filter" rather than a "resonant shunt," as used by Professor Marchant.

As already pointed out, the filter appears to have an advantage over the shunt, in that the condenser has not to withstand the full-line voltage, so that a condenser breakdown would not introduce risk of damage, nor necessitate shutting down.

In conclusion, we think a word of caution should be given. The device was applied by the British Thomson-Houston Company to meet a complaint regarding telephonic interference, and it afforded a solution because the complaint was in regard to two similar notes and not in regard to a number of notes of widely different frequencies which combine together to make a disturbing noise. A number of other investigations of telephone disturbance shows that often the disturbing current is of so complicated a wave shape that the simple devices here under discussion are not applicable without introducing undesirable complications.

Yours faithfully,

R. C. Clinker.

Rugby, October 26, 1923.

OPERATING RESULTS AT POWER STATIONS.

To the Editor of Engineering.

Sir,—Referring to the article which appeared in Engineering of October 26, page 515, describing the results obtained at the Blackburn (East) Generating Station, there is a point relating to the efficiency of generation at light loads which warrants further examination and which, I think, may be of interest to your readers.

From the steam and coal lines, it will be seen that the average night shift load during the trial amounted to approximately 800 kw. (6,400 units generated per shift), and when it is remembered that this small load was carried on a 10,000-kw. turbo-alternator with the boiler plant banked in readiness to receive the daily maximum demand of 8,000 kw., the coal consumption of 4·45 lb. per unit which was obtained appears strikingly low, and, in fact, not appreciably inferior to the results which might be expected under similar conditions of loading from a power station with much smaller generating units installed.

This characteristic of reasonable efficiency on very low machine load factors is common to many of the larger power stations in this country, and supports the contention that in the design of a large power station it is seldom economical to include a smaller generating unit for the sole purpose of carrying the station demand during night shifts or other periods of reduced load.

In the case of Blackburn, the effect on operating efficiency of introducing a 3,000-kw. turbo-alternator to carry the night load, instead of the existing 10,000-kw. set, would be to reduce the total steam consumption of the station by approximately 4,850 lb. per hour, or 38,800 lb. per shift, due firstly to the improved conversion efficiency of a 3,000-kw. set at light loads, and, secondly, to the decrease of approximately 55 kw. in the power taken by the condenser auxiliaries, making it necessary for the 3,000-kw. set to carry a load of only 745 kw. instead of 800 kw. to give the same external output from the station. By reference to the evaporation line, it will be found that this saving corresponds to an improvement in the coal consumption of 5,070 lb. per shift, or, assuming 4,000 hours with such working in the course of a year, to a total of 1,130 tons of a value of, say, 800*l.* per annum.

The capital outlay involved by the installation of a 3,000-kw. set would not be less than 20,000*l.* when the cost of foundations and the value of the engine room space allocated to its use are taken into account, and it is thus evident that the value of the coal saving would be insufficient to bear adequate charges for interest and amortisation on this amount. A further point of interest is that as the output from the station increased, and the 3,000-kw. unit became more fully loaded, the margin of coal saving by comparison with the performance of the 10,000-kw. machine would progressively decrease.

In certain instances, where coal is expensive and load factor low, a case might be made for the installation of a small capacity machine, but it is seldom, if ever, that such considerations apply to large central generating stations supplying power to a variety of industries.

Yours faithfully,

L. C. Kemp.

92, Overstrand Mansions, S.W.11.
October 30, 1923.

The Junior Institution of Engineers.—Sir J. Fortescue Flannery, Bart., M.Inst.C.E., M.I.Mar.E., M.I.N.A., M.I.Mech.E., has accepted the invitation of the Council to become President of the Institution in succession to Captain H. Riall Sankey. His induction will take place at a meeting to be held at the Royal Society of Arts on Friday, December 7, at 7.30 p.m., when he will deliver his presidential address, "Marine Propulsion During Fifty Years."

THREE-MOTOR ELECTRIC BATTERY CRANE.

THE peculiar conveniences and advantages of the battery vehicle are perhaps best illustrated in the case of the portable battery crane, and such appliances are coming into use on an extensive scale. An interesting and very neatly worked-out example of such a machine, specially designed for handling goods on goods platforms, is illustrated in the annexed figures. The crane was constructed by Messrs. John H. Wilson and Co., Limited, of Dock-road, Birkenhead, and will lift 15 cwt. at a radius of 8 ft. and 7½ cwt. at a radius of 14 ft. The lifting speed at full load is 25 ft. per minute, while the travelling speed is 3½ miles an hour. The crane will slew at the rate of four revolutions per minute when loaded. Three motors are fitted for carrying out these three operations, the lifting motor also acting as a luffing motor. All the motions of the crane are controlled from one position in the front part of the revolving superstructure, as will be clear from the general view given in Fig. 1. As will be evident the driver has a very clear view of the load. The battery is fixed at each side of the revolving superstructure as is best shown in Fig. 4.

The battery, which is of the Exide Ironclad type, was supplied by the Chloride Electrical Storage Company, Limited, and has a capacity of 258 ampere-hours on 5 hours' rating. The working voltage is 30. A charging socket and a charge and discharge meter are fitted in connection with the battery. Luffing and lifting are carried out by a 2½ b.h.p. motor, which runs at 750 r.p.m. The travelling motor is similar, while the revolving motor is of 1 b.h.p. and runs at 375 r.p.m. All motors are of the totally-enclosed series-wound, reversing type capable of giving full load output for half an hour with a temperature rise not exceeding 90 deg. F. Controllers are fitted for each motor and there is a single pole handle-type fuse in each circuit. All exposed wiring is run in metal conduits. The lifting barrel is 7 in. in diameter, and is grooved for the wire rope. It is driven by double-purchase machine-cut spur gearing. The lifting rope is ⅜ in. diameter of extra plough steel, and the load is lifted on two falls as will be seen from the figures. The barrel will take sufficient rope for a lift of 35 ft. A claw clutch is fitted for changing over the motor from the lifting to the luffing drum. This latter drum is driven through spur gearing, and the position of the jib can be adjusted with the full load suspended.

The crane is revolved by means of a circular rack with machine moulded teeth and bolted to the superstructure. The revolving motor is carried by the truck and drives the rack pinion through a machine-cut worm gear. The motor and gear can be seen in Fig. 2. The travelling motor is also mounted on the truck and can be seen in Figs. 2 and 3. It is connected to the travelling axle through two separate chains with differential and spur gear drive. The motor is provided with a solenoid brake. The other pair of wheels is arranged to swivel for steering, their position being controlled from the driver's platform on the revolving structure. The arrangement is shown in Figs. 2 and 3. The road wheels are fitted with rubber tyres, and springs are provided over each axle. As will be gathered from the illustrations, the structural parts of the carriage and revolving superstructure are built of steel sections, plates and angles. All principal bearings are bushed with gunmetal, and provision for lubrication is made. Shafts are of Siemen's Martin mild steel, and guards are fitted over all gear wheels. The weight of the crane in working order is 3½ tons. The height to the jib head at 8 ft. radius is 24 ft. 3 in., and at 14 ft. radius 17 ft. 3 in. The carriage has an overall width of 5 ft., and the tail radius of the revolving structure is 4 ft. The wheel base is 5 ft. 6 in.

THE GILSON EFFICIENCY METER.

THE usual way in which the efficiency of a power plant is expressed is by stating the number of pounds of coal burnt for every kilowatt-hour generated. More elaborate methods of stating efficiency are, of course, desirable when close comparisons have to be made, but the simple expression alluded to is likely to remain the standard for all plants without facilities for knowing the exact heat value of the fuel they are using. The Dubilier Condenser Company (1921), Limited, of Ducon Works, Goldhawk-road, Shepherd's Bush, London, have introduced an instrument under the name of the Gilson efficiency meter, for indicating continuously the number of pounds of coal being burnt per kilowatt-hour in a power-station. One of these instruments has been fitted in the station of the Uxbridge Electricity Supply Company, Limited, where by the courtesy of Mr. A. R. Bell, the chief engineer, we have had the opportunity of inspecting it. The indicator, which in the Uxbridge Station is situated on the switchboard gallery, is represented in Fig. 1. The

THREE-MOTOR PORTABLE BATTERY CRANE.

CONSTRUCTED BY MESSRS. JOHN H. WILSON AND CO., LIMITED, BIRKENHEAD.

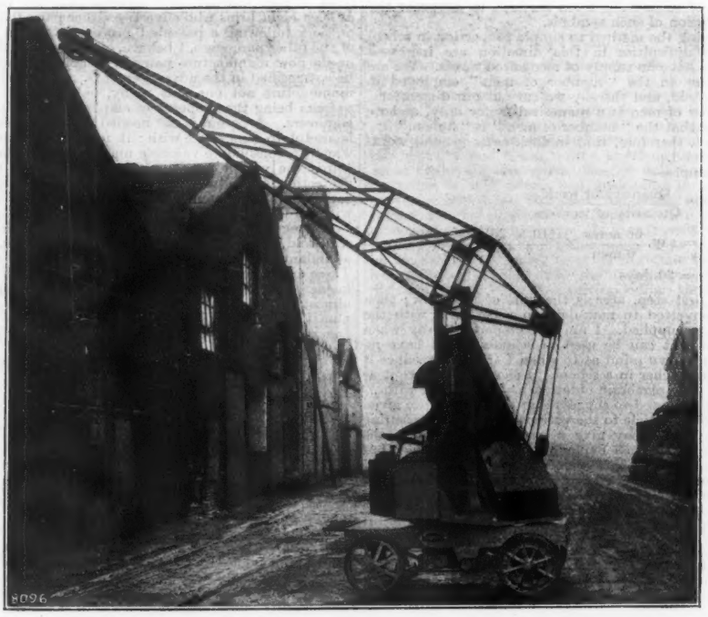
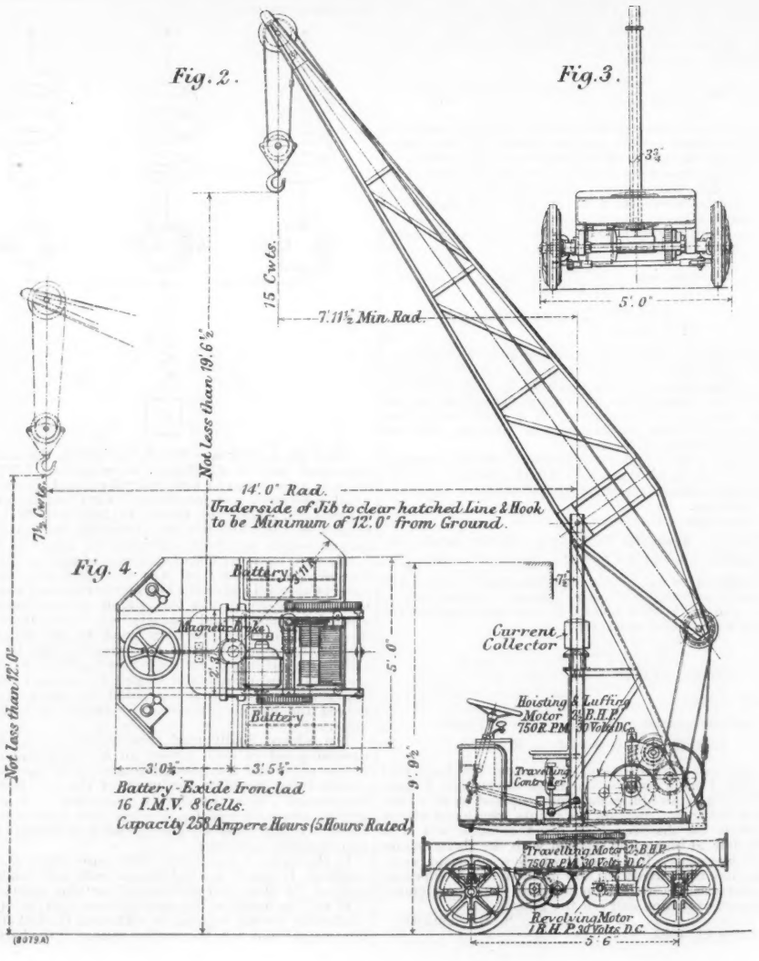


FIG. 1.



THE GILSON EFFICIENCY METER.

CONSTRUCTED BY THE DUBILIER CONDENSER COMPANY (1921), LIMITED, LONDON.

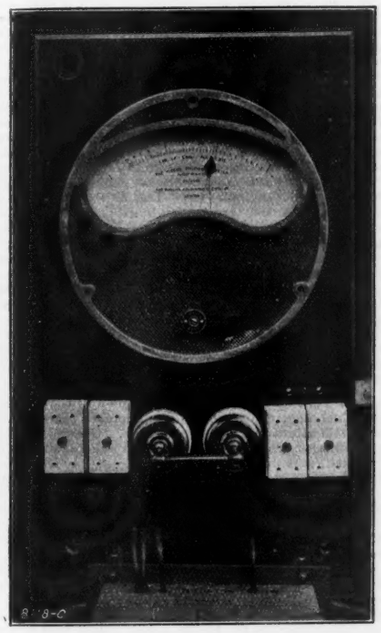
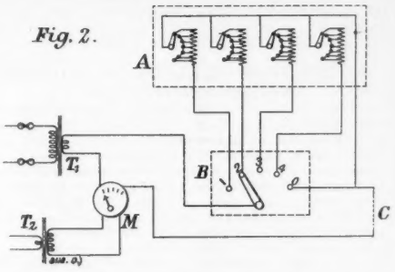


FIG. 1. INDICATING INSTRUMENT.



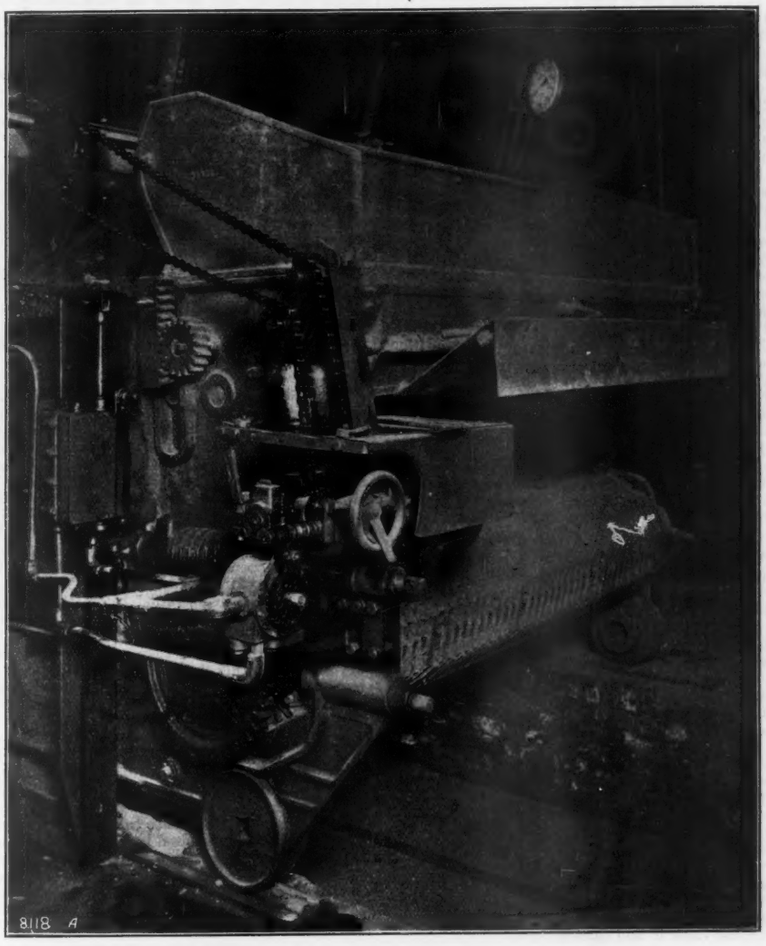


FIG. 3. FITTINGS ON CHAIN-GRATE STOKER.

scale reads from left to right, so that the pointer moves forward as efficiency increases. The range of the scale is from 10 lb. to 2 lb. of coal per kilowatt-hour, the portion between 4 lb. and 2 lb., where most of the readings will be taken, being very open.

The indicating pointer is actuated by the resultant of the current in two windings. The current in one winding is proportional to the output of the station, and the current in the other is inversely proportional to the rate at which coal is being supplied to the furnaces. An increasing load with constant coal consumption, or a decreasing coal consumption with a constant load will therefore cause the pointer to move forward, showing an improvement in efficiency. The interest of the instrument lies in the method adopted to control the "coal circuit" proportionally to the total rate of consumption of coal by the boilers. At Uxbridge the boilers are equipped with chain-grate stokers, and, as has been shown by the success of the Lea coal meter, the rate at which coal is burnt can be determined with sufficient accuracy from the speed of the grates and the height of the fire-door openings.

In the Gilson efficiency meter the act of opening of each fire-door is arranged to insert a resistance proportional to the opening, in an electrical circuit running round the boiler-house. The mechanism is extremely simple, an arm attached to the door operating a sliding contact in a dust-proof iron case alongside. The alteration of each grate-speed operates another switch connected to the change-speed gear in such a way that a definite resistance corresponding to the particular speed in action is inserted in the circuit. The electrical arrangements we have mentioned are shown diagrammatically in Fig. 2. The instrument is shown at M, operated jointly by two low-tension electric circuits. The "load circuit" is fed from the station bus-bars through the current transformer T_2. The "coal circuit" being fed by a potential transformer T_1. Two switches, represented by A and B, in the diagram, are fitted to each stoker. Similar switches are used for each stoker all being in series as indicated by the dotted line C. The selector switch B is operated by the stoker change-speed gear. The four running positions of this switch are marked 1, 2, 3 and 4, while whenever the stoker is stopped the upper switch A is cut entirely out of circuit. This switch A, includes four separate resistances each controlled by its own switch arm. These four switch arms are moved in unison by the furnace door. Only one of the resistances is in circuit at any one time, the one to be working being determined by the selector switch B. The current in the coal circuit will obviously vary inversely with the rate of coal consumption, and will be in phase with the station voltage. The load current will be in phase with the main current, so that the instrument will read pounds of coal per kilowatt-hour whatever the station power factor may be.

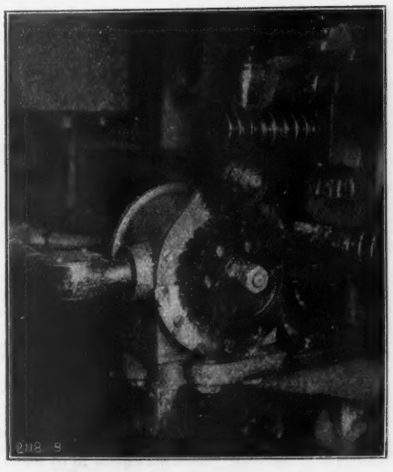


FIG. 4. SELECTOR SWITCH DRIVE.

The apparatus required on each stoker is shown in position in Fig. 3. The attachment of the rectangular resistance switch (A in the diagram) to the fire-door can be seen in the illustration. The selector switch B, operated by the change speed mechanism is also shown to a larger scale in Fig. 4. When the load on the station is steady for considerable periods, and the fires are running without alteration, the instrument will undoubtedly give the efficiency, as measured in pounds of coal per kilowatt-hour, with fair accuracy when once it has been calibrated. The necessary alteration to the grate speeds and fire thicknesses in anticipation of a rising or falling load, will, of course, affect the instrument, and give readings at certain times which bear little relation to the actual operating efficiency, but the instrument is an ingenious one, and anything which emphasises irregularities in the operation of boiler-house plant is to be commended.

INDUSTRIAL NOTES.

The Executive Committee of the Miners' Federation has handed to the Mining Association the new demands as an amendment to the wages agreement. These new demands, of which we gave an outline in a former issue, on page 471 *ante*, are as follow :—

(1) (*a*) That standard profits shall be 13 per cent. of standard wages, instead of 17 per cent. (*b*) That the surplus, after meeting standard costs, shall be divided between wages and profits in the ratio of 87 to 13, instead of 83 to 17.

(2) That the minimum wage shall be standard wages plus 40 per cent. thereof, instead of standard wages plus 20 per cent. thereof.

(3) That further information shall be given under the headings of Form T.S. 1 on Allowances to make up subsistence wages ; timber and pitwood consumed ; other materials and stores consumed ; rents, royalties and wayleaves ; local rates ; insurances other than payments to mutual associations ; mutual insurance associations and payments for workmen's compensation where risk is not covered by insurance ; name of mutual association ; remuneration of directors, general manager, mine managers, and secretary ; remuneration of clerical and administrative staff ; pensions ; general expenses ; coal and power purchased and consumed ; depreciation ; repairs and renewals ; repairs and renewals (colliery wagons) ; surface damage ; restoration ; schedule assessments of workers' houses (less rents receivable) ; welfare levy ; wagon charges (colliery wagons) ; other debits.

(4) That still further information as to costs other than wages should be given, particularly in relation to items about which a difference of opinion might arise as to whether they are properly chargeable to capital or to revenue.

With reference to the Horden Collieries, Limited, Durham, now regarded as a model concern, it is reported that until 1900 no effort was made to work an area of 17,000 acres of coal, half of which is under the sea. An appeal to the public for 250,000*l*., for the formation of the company to enable this coal to be worked, resulted in the subscription of 45,000*l*. only, following upon strong criticism to the effect that the venture was highly speculative and one which did not offer sufficient security. The directors and their friends showed enterprise in the matter, and a share capital amounting to 1,500,000*l*. was ultimately raised ; the collieries are now equipped for a daily output of 12,000 tons. For the first seven years a total of 800,000*l*. was spent on the venture and no dividend was paid. The owners, in this connection, state that under any system of nationalisation, no Cabinet Minister, in view of the reports on the speculative nature of the undertaking, would have felt justified in recommending the development of the coalfield in question, and that the resulting loss to the country in coal and trade, and to labour in work and wages, would have been very great. Private enterprise came in and carried the day.

In a communication to *The Yorkshire Evening News*, Leeds, Sir William Joynson-Hicks, Minister of Health, states that the Minister of Labour and himself have been in collaboration for a very long time trying to devise schemes for dealing with unemployment. The Cabinet Committee, of which both are members, has been in constant session, and every member and official connected with it has given the most wholehearted endeavour to try and find useful work of a commercial character, to save the situation. The whole Cabinet is equally concerned at the position. "If the trade unions," adds Sir William, "would only allow us to do something instead of quarrelling amongst themselves it would be so much happier." He further reports having seen recently the head of a big firm of shipowners who have four large ships on the stocks, the building of which is stopped by reason of the boilermakers' strike ; the shipowner told him definitely that these ships were put in hand very largely for the purpose of helping unemployment, and their construction will be resumed the moment the trade unions allow it. The yards are located where unemployment is rife, and because of the contemptible squabble between two trade unions work cannot be got on with. Sir William wonders sometimes how long decent British workmen will stand such conduct on the part of their so-called leaders. At all events, the trouble in this case is not with the Cabinet, who is keenly anxious to set the wheels of industry going.

Following the decision taken at York, and briefly referred to in our last issue, Mr. F. Bramley, Secretary of the Trades Union Congress, early in the week, invited the Federation of Engineering and Shipbuilding Trades and the United Society of Boilermakers and Iron and Steel Shipbuilders to meet representatives of the Congress yesterday, in London.

H.M. Commercial Secretary at Athens has transmitted to the Ministry of Labour a translation of the text of a revolutionary decision taken by the Greek Government, dated August 20, by which all legally-recognised trade unions and trade union federations are declared to be non-existent on and from the date of the decision, and are to be dissolved by Royal Decrees on the advice of the Greek Government. The public prosecuting authorities are to take over all trade union activities, books and accounts, and their funds are to be deposited, under the care of the same authorities, with the National Bank of Greece, in an account in favour of the Workers' Provident Fund. Legally recognised Workers' Benefit Societies are excluded from the scope of this decision.

A table prepared by the Ministry of Labour gives the following figures for the number of trade unions in Great Britain and Northern Ireland at the end of 1922, with membership and percentage decrease in membership compared with 1921. Number of unions in 1922, 1,190 (in 1921, 1,241) ; males, 4,711,662 (in 1921, 5,609,593) ; females, 868,077 (in 1921, 1,003,253) ; total, 5,579,739 ; (in 1921, 6,612,846) ; equal to a decrease of 15·6 per cent. at the end of 1922, compared with the end of 1921. At the end of 1921 there was a decrease of 20·6 per cent. on the total membership at the end of 1920.

We read in *The Iron Age*, New York, that Labour has definitely entered the field of finance and of the practical ownership of industries. In its annual report to the Portland convention of the American Federation of Labour, the Executive Council of the Federation stated that there are now "practically 23 labour banks either doing business or about ready for business. In addition, about 20 more such banks are now in process of organisation." The actual number of labour banks in operation at the present time is 15. The fifteenth was opened at Cincinnati on October 6, by the Brotherhood of Railway Clerks. Twenty banks probably will be in operation before the end of the present year, and 50 by the end of 1924. The present resources of these banks exceed 50,000,000 dols. This movement, which has shown such a remarkable development during the last three years, in spite of the hostility of some two-fisted fighting leaders of organised labour, calls for attention and close study on the part of intelligent American employers. This is not a movement that has developed out of theory and on the basis of propaganda, but it is a development out of the conditions that have confronted the workers, and it brings with it the promise of complete revolution in trade union methods. Through its new banks and the investment and insurance companies by which they are to be backed, organised labour is for the first time inviting real co-operation—financial co-operation—with it by the general public. The trend is looked upon as being especially significant, as it concerns the status of labour and capital, and, in fact, is making the words almost synonymous.

Board of Architectural Education.—In accordance with the terms of the will of the late Sir Archibald Dawnay, the Royal Institute of British Architects have awarded one scholarship of 50*l*. per annum to Mr. R. W. Donaldson, Liverpool University, and two scholarships of 25*l*. per annum each to Mr. R. H. Turner, Liverpool University, and Mr. A. E. Cameron, Architectural Association. Mr. C. H. Hutton, Liverpool University, who was awarded a scholarship of 25*l*. for 1922–23, has been granted a renewal of his scholarship for 1923–24. On the recommendation of the Board of Architectural Education the Council of the Royal Institute of British Architects have decided to accept, as the standard of general education required of applicants for the Probationership R.I.B.A., the certificates (covering the required subjects) of a number of "Second Examinations" approved by H.M. Board of Education. Further details can be obtained from Mr. Everard J. Haynes, Secretary, Board of Architectural Education, 9, Conduit-street, Hanover-square, W. 1.

The British Cast-Iron Research Association.—This association reports that during the recent visit of Dr. R. Moldenke, of America, to this country, he made some very interesting remarks as to the manufacture and nomenclature of semi-steel. There is no doubt that a better name should be found for it, and that better methods of manufacture will have to be adopted if its production and use are to progress. The association has carried out numerous investigations for its members, and has collected a large amount of data upon the methods adopted by various makers. Although it is not yet in a position to state that definite conclusions have been arrived at it can offer considered advice to its members upon the best melting practice to adopt. This has been done in many cases with the result that mixture and melting processes have been improved. The association is continuing its investigation. A circular giving recommendations for supplying pig-iron on analysis has been circulated to the blast-furnace owners in this country by Dr. R. Moldenke and Mr. W. Wood on behalf of the American Society for Testing Materials. The recommendations will be carefully considered by the association.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Sheffield heavy trades are still marking time in anticipation of the big contracts which are undoubtedly on the way. In the meantime there has been no rush of orders for heavy steel, while in respect of pig-iron, billets and similar material there is little new to report except increased competition from the Belgian and Luxemberg markets. In the steel trade generally there is much in and out working, and substantial orders are badly wanted at the railway mills and in tyre departments. Few firms have anything like a continuous run. Axles remain one of the most active lines and good business is being done in buffers and springs. Inquiries for prices of steel are fairly numerous, but buyers are not likely to give out orders until further substantial contracts come to hand. Makers of crucible steel, tools and files report conditions somewhat brighter, but none of these works have much work on hand, and all have a lot of leeway to make up. The announcement that several new cruisers are to be built has been happily received, for Sheffield has still big interests at stake, and much money sunk in armament plant. Guns, armour plates, turbine parts, castings, shafting and many others things are essentially local specialities, and big contracts of this kind are bound to bring work to the city. Steel scrap still maintains a firm tone, and though buying is still inconsiderable, holders are expecting a brisk demand as soon as there is any marked move in the steel trade. At present South Wales, where the furnaces are on full time owing to the demands for tin plate, is one of the best customers.

South Yorkshire Coal Trade.—Business in the Sheffield Coal Exchange continues only moderate, there having been little alteration during the week. Generally speaking, collieries are well occupied, and where short time is worked, it is due to the inadequate supply of wagons. The export trade in best steam hards is brisk, and the home demand satisfactory. Railway companies are now taking their winter supplies. Cobbles and nuts are in good request, and recent prices firmly maintained. In slacks there is a steady call for the better qualities, the only weakness observable being in inferior sorts. A steady demand exists for furnace and foundry coke, stocks of which are in a somewhat depleted condition. Gas cokes are moving freely. Prices are as follows :—Best handpicked branch, 31*s*. 6*d*. to 32*s*. 6*d*. ; Barnsley best Silkstone, 27*s*. 6*d*. to 29*s*. ; Derbyshire best brights, 27*s*. to 29*s*. ; Derbyshire best house coal, 23*s*. to 24*s*. ; Derbyshire best large nuts, 21*s*. to 22*s*. 6*d*. ; Derbyshire best small nuts, 15*s*. to 16*s*. ; Yorkshire hards, 21*s*. to 23*s*. ; Derbyshire hards, 20*s*. to 22*s*. ; rough slacks, 11*s*. 6*d*. to 13*s*. 6*d*. ; nutty slacks, 10*s*. to 12*s*. ; smalls, 7*s*. to 9*s*.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Transactions in Cleveland pig-iron are not so numerous or so heavy as last week and the week previous, but a moderate business is still passing, and the recently advanced prices are well upheld, producers and merchants reporting sales at them on both home and export account. All qualities have become scarce. No. 1 is almost unobtainable and what parcels come on the market command 107*s*. 6*d*. ; No. 3 g.m.b. is still put at 100*s*., but that is rather a buyer's than a seller's quotation ; foundry 4 was quite 99*s*. ; and No. 4 forge was 97*s*. 6*d*.—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—A steady trade is passing in East Coast hematite. More sales to the Sheffield district are reported, and inquiries are circulating for supplies for Wales, whilst Continental customers are still in the market. Values are slowly but steadily moving upward. For home and export trade 100*s*. is now the minimum for Nos. 1, 2 and 3, and 100*s*. 6*d*. has been paid for No. 1.

Foreign Ore.—There is very little doing in foreign ore. Best rubio is reported to have been sold this week at 23*s*. c.i.f. Tees, and market rates for imported ore are based on that figure.

Blast-Furnace Coke.—Durham blast-furnace coke is quoted 39*s*. delivered to local consumers, but this concession figure is quoted to regular customers only.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are a good deal better placed than they have been. In several branches trade is expanding and some rather substantial sales of steel materials are understood to have been made. Inquiries in the market promise to result in further contracts being arranged. Among the principal market quotations are :—Common iron bars, 12*l*. ; iron rivets, 14*l*. ; packing (parallel), 8*l*. 10*s*. ; packing (tapered), 11*l*. 10*s*. ; steel billets (soft), 9*l*. 10*s*. ; steel billets (medium), 10*l*. ; steel billets (hard), 10*l*. 5*s*. ; steel boiler plates, 13*l*. ; steel ship, bridge and tank plates, 9*l*. 15*s*. ; steel angles, 9*l*. 5*s*. ; steel joists, 9*l*. 10*s*. ; heavy steel rails, 9*l*. 10*s*. ; fish plates, 12*l*. 10*s*. ; black sheets, 14*l*. 5*s*. ; and galvanised corrugated sheets, 19*l*. 5*s*.

Royal Institute of British Architects.—At the request of the authorities of the British Empire Exhibition, this Institute have undertaken, with the assistance of the Architecture Club, to arrange an Exhibition of Modern Architecture at Wembley, which will be open from May 19 to June 28, 1924, and will consist of photographs and models of buildings erected within recent years from the designs of living architects. Space has been allotted to the Dominions and Dependencies.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Trade Position.—The state of trade in this country has not improved of late and producers of all kinds of material are finding it increasingly difficult to carry on. With so many thousands of workers unemployed there is a big scarcity of money, and the spending power of the masses is very much reduced with the consequent result that the demand for everything is very poor. The prospect of an early return of the boilermakers to work is the one bright spot on the horizon at the moment, and although this would not mean an immediate accession of new work it would be one step towards better times. As there is a lot of work awaiting their efforts once they are working again shipbuilders would be in a better position to push for new contracts, and it is believed that a number of shipowners are prepared to consider the placing of orders for new tonnage. In that case, unemployment in the steel and iron trades would be reduced and general business would also benefit. There is certainly a better feeling at the moment, but the actual demand is still very small.

Scottish Steel Trade.—As in other branches of industry the Scottish steel makers are finding things very stiff still, particularly in shipbuilding material. The demand for plates is just about as low as it has ever been, but a few lines have lately been secured for sections. Competition for any orders coming on to the market is very keen and all inquiries are eagerly followed up. The makers of steel sheets continue fairly busy on the lighter gauges and quite a respectable tonnage is going abroad, but the heavier sorts are not in much demand meantime. Prices all round are nominally unchanged and are as under:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, 12*l.* 10*s.* per ton—all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable iron makers again report no improvement in the demand for bar iron this week. Conditions at the works are very unsatisfactory, as orders coming in are of very small tonnage and do not give employment to many men for any length of time. The re-rolled steel bar branches are holding on wonderfully well and a fair trade is passing. Prices are unchanged with "Crown" bars called 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—Little or no change falls to be reported in the state of the Scottish pig-iron trade this week. Current business is not very heavy, but the forward position shows signs of improvement, and a number of bookings are recorded. Prices continue firm, particularly for foundry grades, and the following are to-day's quotations:—Foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards. Hematite iron is still very slow in demand, and the price is unchanged at 5*l.* 5*s.* per ton, delivered at the steel works.

¶*Scottish Pig-Iron Shipments.*—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, October 27, amounted to 1,334 tons. Of that total 958 tons went overseas and 376 tons went coastwise. For the corresponding week of last year the figures were 1,506 tons overseas and 167 tons coastwise, making a total of 1,673 tons.

Shipbuilding.—The shipbuilding returns for the past month were again disappointing, even although the tonnage was the largest since the month of May. The total Scottish output was 12,039 tons, of which the Clyde claimed all but 20 tons which was for a motor-boat launched at Banff on the Moray Firth. The Clyde total for the year to date is now 167,241 tons, which is a very poor total when compared with former years, but when the conditions prevailing during the past six months are taken into account it is not so bad. For the first four months of the year the output was about 120,000 tons, and for the remainder to date it has been about 47,000 tons. The position at the yards is without change, and no betterment can possibly take place until the lock-out of boilermakers is over. There is a very hopeful feeling that the present negotiations will end successfully, but even if they should there is little prospect of a revival in the shipbuilding industry. Work on the ships now on the stocks and the laying down of the contracts on hand would not make for any great activity, but unemployment would be considerably reduced thereby. New work given out recently has not been heavy, but the prospect of two Government light cruisers being secured by the Clyde is quite encouraging. These would make two yards busier and incidentally several other branches of industry would benefit. The point which cannot be lost sight of at the present time is that many owners state most emphatically that the carrying trade is not profitable just now, and to order new vessels is out of the question until general trade improves.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Mr. H. H. Merrett, partner in the firm of Messrs. D. R. Llewellyn, Merrett and Price, Limited, yesterday returned to Cardiff, after a flying visit to the United States, with several considerable contracts for the delivery of Welsh anthracite coal over next year. Mr. Merrett has also gained some important and interesting knowledge of the state of the American coal-mining industry, and after carefully considering all the facts has come to the conclusion that there is no real danger of American bituminous coal becoming securely entrenched in either the European or South American markets in serious competition with Welsh coal. In regard to anthracite coal practically all the serious prejudices which had existed have been overcome, and it has been proved on analysis that Welsh anthracite as at present mined and treated is the purest in the world. In connection with the opening up in London of credits for 4,000,000*l.* by Germany for the purchase of British coal, it is now stated that the requirements of both coal and coke from South Wales will be larger than was at first anticipated. In fact, it is reported that the business on German account has been entrusted to Messrs. Baldwins, Limited, who are large producers of both coal and coke, and with Messrs. Stephenson, Clarke and Co., Limited, who are jointly with the Powell Duffryn Steam Coal Company, Limited, the holders of the share capital of the Maris Export and Trading Company. Contract business on account of next year is still the principal topic of interest amongst operators, and a number of fresh orders have been placed during the past week on the basis of 27*s.* 6*d.* for best Admiralty large, 27*s.* for superior seconds and 26*s.* 6*d.* for ordinary seconds, while ordinary Monmouthshires have been booked up at 25*s.* and 25*s.* 6*d.*, and the best classes at 26*s.* 6*d.* to 27*s.* Smalls for delivery next year range from 15*s.* 6*d.* to 17*s.* 6*d.*, according to quality. In November and December the wages of colliery workers in South Wales are to be reduced from 41·47 per cent. to 28·66 per cent. above the 1915 standard, which is only 0·66 per cent. above the minimum. The wages payable in the last two months of the year are based on the results of the trade in July and August, when the surplus available was 600,000*l.* less than that for May and June. The reduction was chiefly due to the effects of the holidays on outputs, though prices were also decreased in July and August. The proceeds for July and August combined were 8½*d.* per ton less than in May and June. The price in July was 3½*d.* less than the average pithead price in June, and in August 2*d.* less than in July. In August the wages cost was 5*d.* per ton more than in July, and other costs 6½*d.* per ton higher, making a total increase in costs in August of 11½*d.* per ton above July. This increase in cost was mainly due to the loss of output caused by the three days' holiday and subsequent absenteeism from work. In fact the output in August was 348,000 tons less than in July and 600,000 tons below a normal month's production.

Iron and Steel.—Exports of iron and steel goods from South Wales last week amounted to 12,160 tons, compared with 12,200 tons in the previous week. Of the total, 6,915 tons comprised tin and terne plates, against 7,022 tons; 1,513 tons black plates and sheets, against 3,968 tons; 1,402 tons galvanised sheets, against 964 tons, and 2,331 tons of other iron and steel goods, against 1,155 tons.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—In order to familiarise members with the site and accommodation of the new offices at Watergate House, Yorkbuildings, Adelphi, W.C. 2, the President and Council of the Institution held a reception there on Tuesday, October 30. The new offices occupy the whole of the second floor of Watergate House, which is within two or three minutes' walk of the three Charing Cross stations. They include a library and lounge for the convenience of members.

THE SOUTH WALES INSTITUTE OF ENGINEERS.—The proceedings of this Institute are now available, down to Vol. XXXIX, No. 3, issued on October 9, which gives the report of the summer meeting, held in June last, in Scotland, and other matter, including a paper on "The Anthracite Problem." Its price is 5*s.* The issue No. 2 of the same volume, also published on October 9 (price 10*s.*), deals with the spring meeting, held in Cardiff, in March, and contains papers on a number of interesting subjects, with the discussion thereon. We may also mention Vol. XXXVIII, No. 8, issued on September 26 (price 10*s.*), containing papers and discussion on "Wireless Telephony," "Power Plant Testing," "The Tinplate Trade, Modern Machinery," "Furnace Design," &c.

THE ELECTRICAL TRADES BENEVOLENT INSTITUTION.—This institution was founded about 18 years ago, with a view to provide temporary relief in some cases, permanent pensions in others, for those connected with the electrical industry, who through failing health or old age could no longer support themselves and their dependants. Up till the present, the institution has not been able to carry out the second of its objects, the provision of pensions to the worst cases, owing to lack of funds. Contributions can be sent to the president, Sir Philip M. Nash, or to the hon. secretary, Mr. F. B. O. Hawes, 18-21, Park Mansions, Vauxhall-park, South Lambeth-road, S.W.8. The aims of the institution deserve every encouragement on the part of all firms dealing with electric machinery and materials.

TRANSPORT AT THE BRITISH EMPIRE EXHIBITION (1924).—It is announced that plans are being made to provide transport at the British Empire Exhibition next year, on three systems. Electric cars will provide service inside the exhibition on all the roads in the grounds. In addition to this two systems of transport will be arranged between a central point in the exhibition, and the two railway stations of Wembley Hill and Wembley Park. For the latter service the "never-stop" railway of Mr. Yorath Lewis will be installed. Mr. Lewis has had an experimental line on his system in operation at Southend, but the exhibition line will be on a much larger scale, and will have a total length of about three miles. Speeds up to 20 miles per hour are to be attained. For serving Wembley Hill Station the "Roadrail" system will be used. In this the tractor, in addition to carrying wheels running on rails, is provided with rubber-tyred driving wheels running on concrete or other road surfaces whereby additional grip is attained.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 2, at 6 p.m., at Storey's Gate, St. James' Park, S.W. 1. Thomas Hawksley Lecture, "The Mechanical Problems of the Safety of Life at Sea," by Sir Westcott S. Abell, K.B.E., M.Eng.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 2, at 7.30 p.m. at 39, Victoria-street, S.W. 1. Lecturette, "Hydraulic Propulsion," by Mr. D. V. Hotchkiss. Friday, November 9, at 7.30 p.m., Lecturette, "Amateur Cinematography," by Dr. C. K. Mees.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, November 3, at 4 p.m., in the College of Technology, Sackville-street, Manchester. "Test Bars—Making and Testing Them," by Mr. J. S. Glen Primrose, A.R.T.C.

BRADFORD ENGINEERING SOCIETY.—Saturday, November 3, at 6.30 p.m. Lecture in the hall of the Technical College, by Mr. E. L. Rhead, M.Sc. (of Manchester), on "Non-Ferrous Metals and Alloys in Engineering." Illustrated by lantern slides. (Joint meeting with the Institution of British Foundrymen, W.R. Yorks Branch.)

THE JUNIOR INSTITUTION OF ENGINEERS, NORTH KENT SECTION.—Saturday, November 3, at 8 p.m., at the dining hall of the Messrs. J. and E. Hall, Limited, Dartford. Presidential address by Major W. G. Wilson, C.M.G., "Some Problems connected with the Transmission and Controlling Mechanism of the Tanks." (Slides.)

THE SOCIETY OF ENGINEERS.—Monday, November 5, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, W., when a paper will be read on "Lubrication," by Mr. William Lee, chief chemist of Silvertown Lubricants, Limited.

BRADFORD ENGINEERING SOCIETY.—Monday, November 5, at 7.30 p.m. Lecture in the hall of the Technical College, by Mr. T. Elliott (of Manchester), on "Jigs and Fixtures." Illustrated by lantern slides, blackboard illustrations and actual samples.

THE INSTITUTE OF TRANSPORT—Monday, November 5, at 5.30 p.m., in the Lecture Theatre, Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Fourth Annual General Meeting. At conclusion of meeting a paper will be read by Mr. T. Salkield on "A Transport Adventure in Persia."

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 6, at 6.30 p.m., at 85-8, The Minories, Tower-Hill, E. 1. "Gear Cutting," by Messrs. R. J. McLeod and T. Calderwood.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 6, at 6 p.m. Opening meeting. Address by Sir Charles Langbridge Morgan, C.B.E., the President, and presentation of medals awarded by the Council. The President will receive the members in the Great Hall after the meeting.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, November 7, at 7 p.m., Engineers, Club, Coventry-street, London, a lecture entitled "Some Common Faults in Fan Design and Application" will be given by Mr. F. G. Whipp, A.M.I.Mech.E.

ROYAL SOCIETY OF ARTS.—Wednesday, November 7 Inaugural address of the 170th session. "Exhibitions," by Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council and a Vice-President of the Society. The chair will be taken at 8 p.m.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, November 8, at 8 p.m., at the Royal School of Mines, South Kensington. Lecture, "Some Impressions of American Non-Ferrous Metallurgy," by Dr. W. Rosenhain, F.R.S.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, November 9, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. Sorby lecture on "Metallurgical Problems Present and Future," by Dr. W. Rosenhain, F.R.S.

INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, November 14, at 7.30 p.m. A meeting will be held at the Engineers' Club, Coventry-street, London, W. 1, when the following two papers will be read and discussed—(1) "A Study of the Conditions of Constant Rate of Flow in Filter Presses," by Messrs. M. B. Donald and R. D. Hunneman; (2) A "Study of the Absorption Tower," by Messrs. M. B. Donald and C. W. Tyson.

METALLURGY IN BIRMINGHAM.—Sir Robert A. Hadfield, Bart., delivered an address last Tuesday before the Birmingham University Metallurgical Society, in the Metallurgical Department of the University of Birmingham. The address dealt with the city, its workers and University, also with metallurgy and metallurgical chemistry and their application to modern engineering. Previous to giving his address, Sir Robert received from the Principal—Mr. Grant Robertson—the Thomas Turner Gold Medal, as a mark of appreciation of the work he had carried out in Metallurgy. Sir Robert is the first recipient of this prize. On the following day, Sir Robert opened the new research laboratory and lecture room of the Municipal Technical School, Birmingham. In his address on this occasion, he dealt mostly with the corrosion problem, and said it was so important and fascinating a problem that he wondered Mr. Bernard Shaw had not taken it in hand. To the chemist, "The Conquest of Corrosion" was really far more interesting than "Back to Methuselah," because one represented progressive advance and the other appeared to be a backward movement.

THE CONSTRUCTION OF A REINFORCED CONCRETE WORKSHOP BUILDING AT ELSINORE.

MESSRS. SAXILD AND PARTNERS, ENGINEERS, WESTMINSTER.

(*For Description, see Page 547.*)

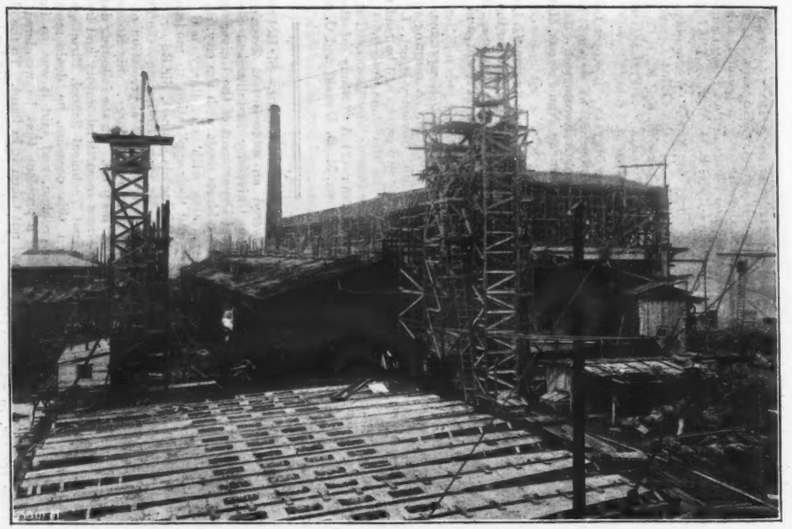


FIG. 18. FLOORBEAMS IN MOULDING YARD.

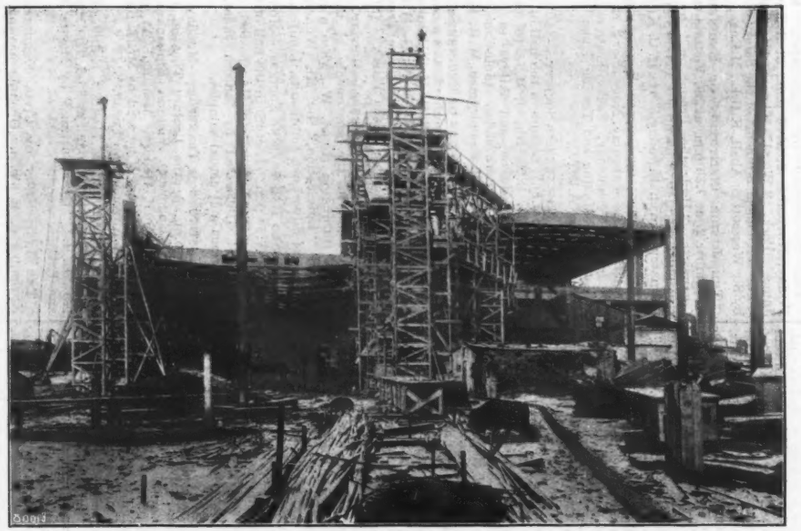


FIG. 19. TOWERS USED FOR HOISTING BEAMS ON TO TEMPORARY SCAFFOLDING.

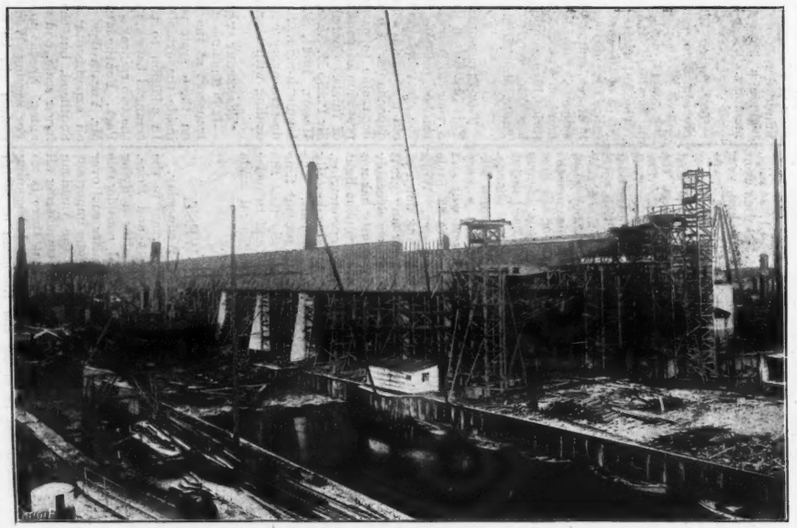


FIG. 20. EAST SIDE OF BUILDING SHOWING BUTTRESSES.

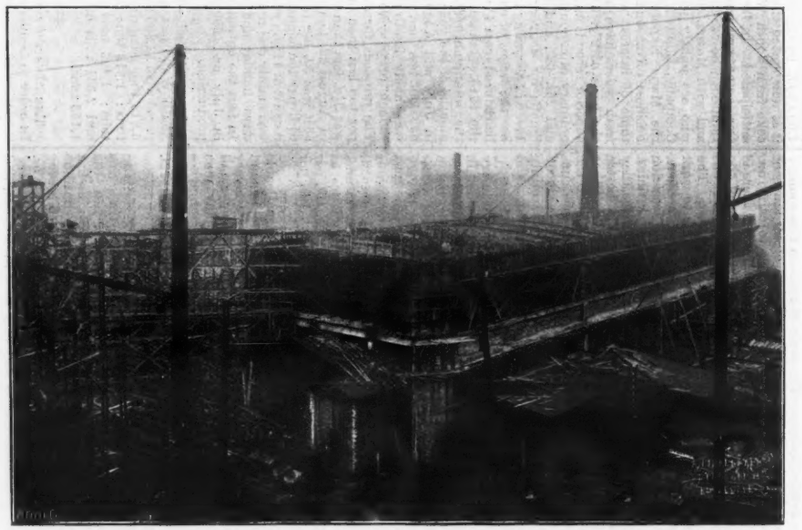
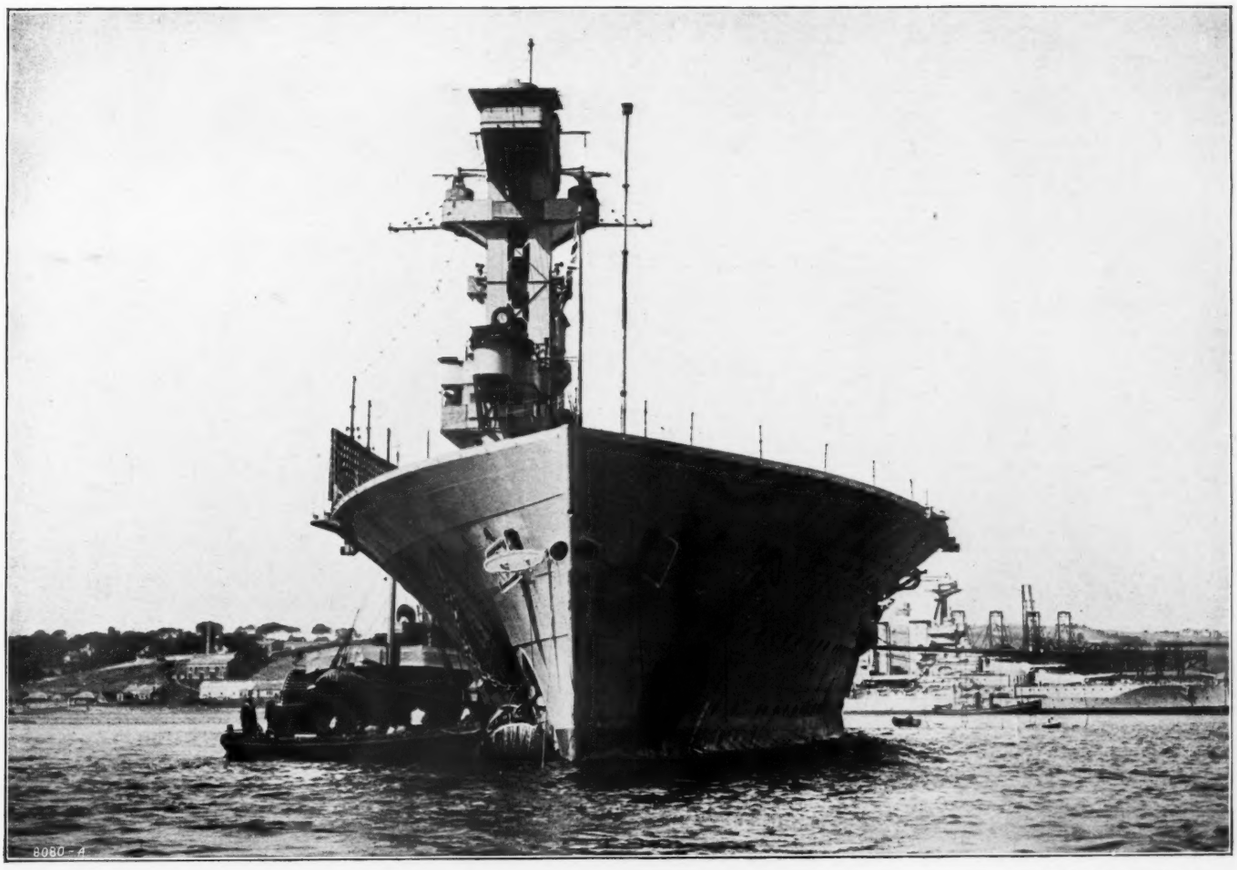


FIG. 21. WEST BAY SHOWING SHUTTERING FOR UPPER STOREY.

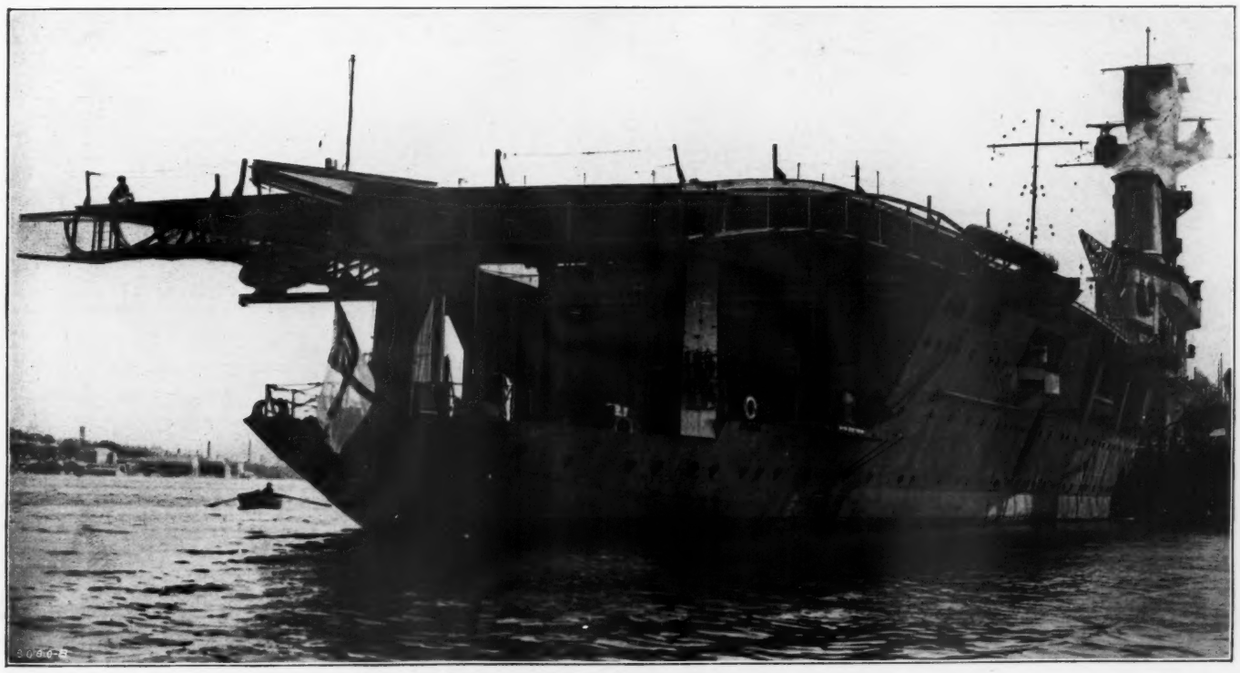
H.M. AIRCRAFT CARRIER "HERMES."

(*For Description, see Page* 564.)



[*Photo: Abrahams & Sons.*

Fig. 1. Bow View of Ship.



[*Photo: Abrahams & Sons.*

Fig. 2. Stern View of Ship.

(*To face page* 564.)

Fig. 21. West Bay showing Shuttering for Upper Storey.

Fig. 20. East Side of Building showing Buttresses.

BRITISH NAVY AIRCRAFT CARRIERS.

(*For Description, see Page* 564.)

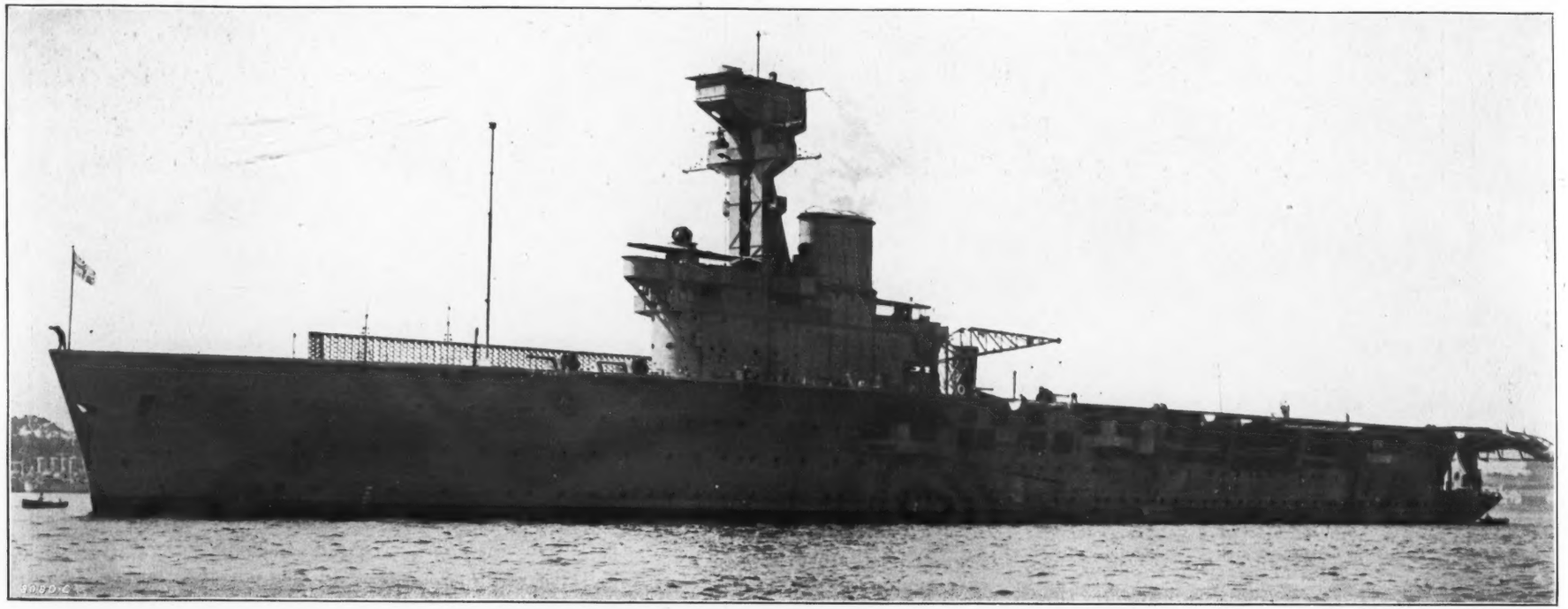


FIG. 3. H.M. AIRCRAFT CARRIER "HERMES." [*Photo: Abrahams & Sons.*

FIG. 4. H.M. AIRCRAFT CARRIER "FURIOUS." [*Photo: Stephen Cribb.*

FIG. 4. H.M. AIRCRAFT CARRIER "FURIOUS." [Photo: Stephen Cribb.

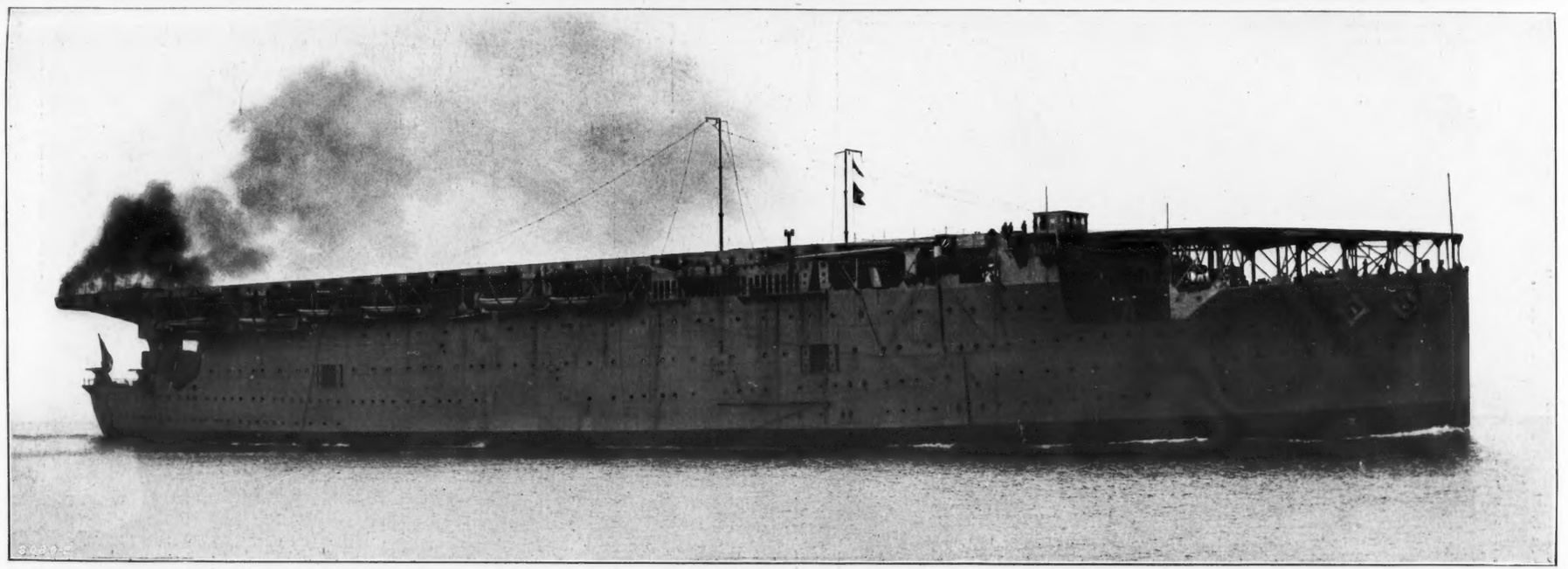


FIG. 5. H.M. AIRCRAFT CARRIER "ARGUS." [Photo: Stephen Cribb.

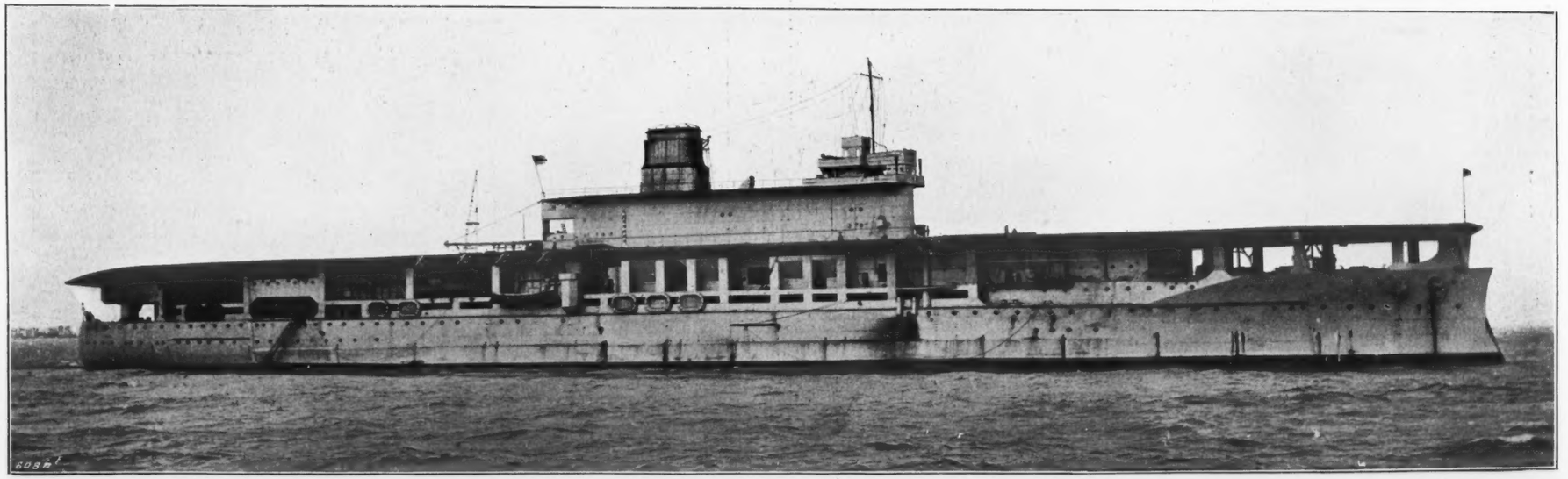
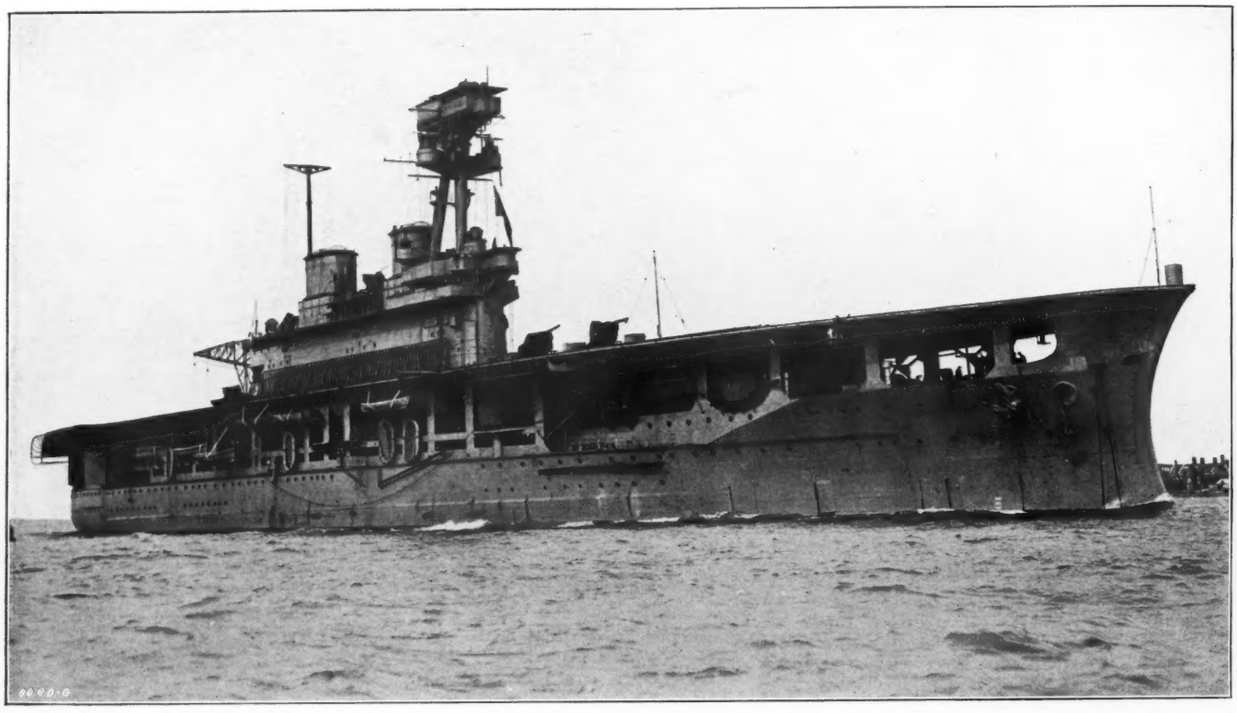


FIG. 6. H.M. AIRCRAFT CARRIER "EAGLE," BEFORE RECONSTRUCTION. [Photo: Stephen Cribb.

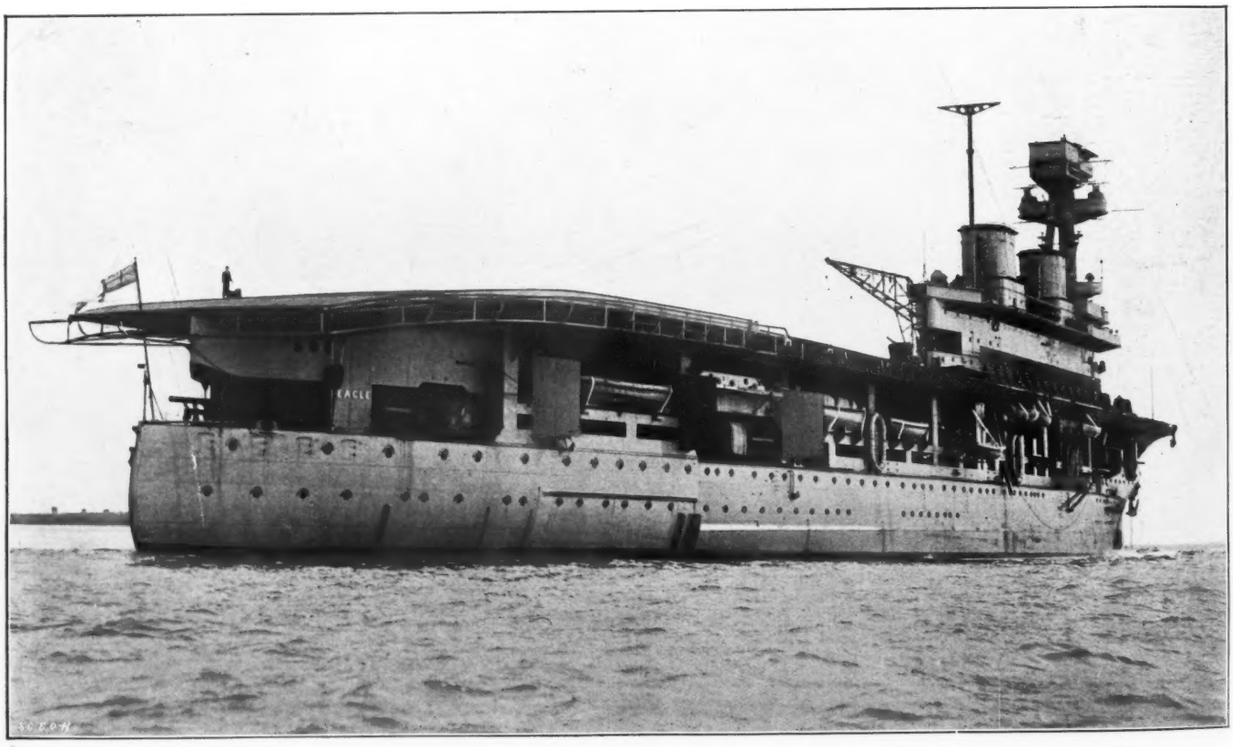
H.M. AIRCRAFT CARRIER "EAGLE."

(For Description, see Page 564.)



[*Photo: Stephen Cribb.*

FIG. 7. BOW VIEW OF SHIP AFTER RECONSTRUCTION.



[*Photo: Stephen Cribb.*

FIG. 8. STERN VIEW OF SHIP AFTER RECONSTRUCTION.

(To face page 565.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance :—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA : Gordon and Gotch, Limited, Melbourne ; Sydney ; Brisbane ; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels : E. F. Satchell, 86, Rue du Tabellion.

CANADA, Toronto, Ont. : Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH : John Menzies and Co., Limited, Rose-street.

FRANCE, Paris : Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Office de Publications Commerciales, 167 Rue Montmartre, Paris (2e).

GERMANY : Hermann H. Fromm, Potsdamerstr 105A, Berlin, W. 35. A. Twietmeyer, Leipzig.

GLASGOW : William Love, 221, Argyle-street. John Menzies and Co., Limited, West Nile-street.

INDIA, Calcutta : Thacker, Spink and Co. Bombay : Thacker and Co., Limited.

ITALY : U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.

LIVERPOOL : Mrs. Taylor, Landing Stages.

MANCHESTER : John Heywood, 143, Deansgate.

NEW ZEALAND : Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania : Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43,

ROTTERDAM : H. A. Kramers and Son, Limited.

SOUTH AFRICA : Central News Agency, Limited, Head Office—Johannesburg ; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons (South Africa), Limited, 29, Long-street, Capetown.

TASMANIA : Gordon & Gotch Prop'ty, Ltd., Launceston : Hobart.

UNITED STATES : For Subscriptions, New York : W. H. Wiley, 432, Fourth Avenue. For Advertisements : J. S. Allan, 30 Church-street, New York.

CONTENTS.

	PAGE
The Construction of a Reinforced Concrete Workshop Building at Elsinore (*Illus.*)	547
The Scientific and Industrial Research Department in 1922–3	551
Some Tests of an Air-Ejector Pumping Viscous Humus (*Illus.*)	552
Crude Oil Motor Locomotive (*Illus.*)	553
The Darimont Primary Cell	555
The Late Dr. C. P. Steinmetz	555
The Society of Glass Technology	556
Letters to the Editor.—Dimensional Arithmetic. The Value of Patents. "A Method of Improving the Wave-shape of Alternators." Operating Results at Power Stations	556
Three-Motor Electric Battery Crane (*Illus.*)	558
The Gilson Efficiency Meter (*Illus.*)	558
Industrial Notes	560
Notes from South Yorkshire	560
Notes from Cleveland and the Northern Counties	560
Notes from the North	561
Notes from the South-West	561
Notices of Meetings	561
Developments and Prospects in Marine Engineering	563
British Navy Aircraft Carriers (*Illus.*)	564
Steaming Lancashire Coal in Vertical Gas Retorts	565
Locomotive Connecting-Rod Failures	566
The Late Mr. H. A. Ivatt (*With Portrait*)	566
The Motor Exhibition at Olympia	567
Notes	568
Notes on New Books	568
Books Received	569
Diagrams of Three Months' Fluctuations in the Prices of Metals	569
0–8–4 Tank Locomotive for the London, Midland and Scottish Railway (*Illus.*)	570
The Mid-Lancashire Electricity District	570
Wind-Driven Electric Lighting Plant (*Illus.*)	571
Practical Applications of Gas Welding	571
The Causes of Rapid Corrosion of Condenser Tubes (*Illus.*)	572
Catalogues	576
ENGINEERING Patent Record (*Illus.*)	577

One Two-Page Plate and Two One-Page Plates.—BRITISH NAVY AIRCRAFT CARRIERS.

ENGINEERING.

FRIDAY, NOVEMBER 2, 1923.

DEVELOPMENTS AND PROSPECTS IN MARINE ENGINEERING.

THE pious Arab thanked heaven for a diversity of creatures, but we doubt whether any corresponding spirit of gratitude inspires the meditations of the modern marine superintendent when he contemplates the diversity of methods of ship propulsion offered to him to-day. He must, we imagine, look back with regret to the time when developments in marine practice took the form of improvements instead of revolutions, and consisted merely of step-by-step advances along well-established lines. Much, no doubt, was accomplished in this way, and the stock assertion that the tendency of the times has been to sacrifice quality to output is entirely without foundation. Forty years back, no doubt, skilled fitters formed a larger proportion of engineering employés than they do to-day, though it is equally probable that highly skilled mechanics are more numerous than ever. Their work is, however, more specialised, and in ordinary commercial engineering there is less need for the fitter, whose job was, in the main, to make good by his craftmanship, imperfections which have been abolished by the introduction of more and better machine tools. As a consequence, there has been a steady and marked improvement each decade in the average standard of workmanship, and the marine engine shared in this general progress. Moreover, more and better auxiliaries were also installed. Nevertheless, the marine engine remained essentially unaltered in type, and marine superintendents were loth to introduce even minor novelties when these made any marked departure from standard types. The Michell thrust bearing constitutes a case in point. The imperfections of the ordinary thrust block were known and admitted, but it was generally felt better to face familiar perils than to adventure into new paths, no matter how strong the case for the change might be from the logical standpoint. The single collar thrust had accordingly to bide its time until the introduction of the geared turbine emphasised the defects of its rival.

It will be remembered, moreover, that the turbine itself had great difficulty in getting a footing at sea. Indeed, certain marine engineers possessed of painfully acquired experience in high-class marine engine design, long refused to admit the possibility that this experience had suddenly become obsolete and that a new departure must be faced. Fortunately, this attitude was specially pronounced in Germany, with the result that our own warships proved superior in speed to their opponents.

A similar incredulous spirit ruled in the merchant and mail services, and in spite of the records obtained it was impossible to persuade any of our large railway companies to act as pioneers, anxious though they were to improve their cross-channel services. Perhaps there is nothing surprising in this. The bigger an undertaking, and the less it is controlled by a single individual, the more does the directorate regard itself as occupying a quasi-trustee position, and is hence indisposed to adopt novel ventures ; whilst in the case of public bodies this feeling is carried so far that some years back a municipality refused to order a steam turbine of 3,000 kilowatts from a British firm, because up to date this firm had not gone beyond a rated capacity of 2,500 kw.

Since the war hard times have compelled shipowners to be less irresponsive to new ideas. It is true that even at the best of times freights have been remarkably low in comparison with the work done. In pre-war days it was considered a marvel that on certain American railway lines the average freight rate was less than ¼d. per ton mile, but at the same time the shipowner was carrying bagged maize from the Cape to England for a freight of 10s. per ton, or about one-fiftieth of a penny per ton mile. To-day freights have gone up, owing to higher fuel costs and higher wages, and as a consequence shipowners have proved less irreceptive than formerly of ideas promising a reduction either in fuel costs or labour costs.

That they have now an ample variety of choice is clearly set forth in the able and interesting presidential address delivered recently to the Belfast Association of Engineers by Mr. W. C. Ward, M.I.N.A. Some of the timorous indeed may fear that the choice offered them bears an uncomfortable resemblance to that offered to Alice in Wonderland by the Cheshire Cat, when he told her that if she proceeded in one direction she would meet a mad hatter and in the other a mad March hare. Indeed, all new departures necessarily involve risk, but that a large proportion of our shipowners are sufficiently enterprising to face this, is clearly shown by the figures quoted by Mr. Ward, from which it appears that in the year 1918-19 the total steam and motor tonnage was 3,760,806 gross tonnage, of which 70 per cent. was equipped with ordinary steam reciprocators, 28 per cent. with turbines, and 2 per cent. with internal combustion engines. In 1921-22 the gross tonnage launched was 2,317,513, of which 61·3 per cent. was equipped with ordinary marine engines, 29 per cent. with geared turbines, and 9·8 per cent. with motors. The rapid increase in the proportion fitted with internal combustion engines is notable, but it will be seen that in spite of some adverse experiences the geared turbine is so far holding its own.

Mr. Ward appears to incline to the opinion that the remedy for geared turbine troubles lies in the adoption of tougher and more ductile steels, in greater accuracy in gear cutting (allowance being made for the effects of temperature and torsion), in greater care in securing alignment and rigidity, reduced tooth pressures, and perhaps in the adoption of the Nodal drive. For our own part we have hopes that the simple procedure of using a relatively soft steel for the pinions may prove, as advocated by Sir Charles Parsons and his colleagues, in a paper read last spring before the Institution of Naval Architects, a simple and effective cure, since, as was pointed out at the same meeting by Admiral Sir George Goodwin, most of the other remedies proposed involved costly construction and difficult maintenance. A high-grade and expensive

steel is not necessarily the best for all purposes, and with a softer quality may prove practicable for the pinion to shape itself to a bearing, in which case calculation shows that the stresses will be moderate even under higher loadings than are customary at present. It was stated at the Naval Architects' meeting that the plan was being tried on a vessel belonging to the enterprising firm of Messrs. Alfred Holt & Co., and we ought thus soon to have definite data as to the value of the proposal.

The Fottinger transmitter, to which Mr. Ward also referred, suffers from the drawbacks of a small reduction ratio, and is thus suitable only for fairly high-speed vessels. The only vessel now afloat on which it is employed is, Mr. Ward stated, the Tirpitz. We understand, however, that, as originally equipped, it was found impossible to run the machinery of this vessel at anything like full power, owing to some peculiar ideas in the matter of lubrication embodied in the machinery by its German designers. When taken over as one of the Reparation vessels it was found necessary to fit Michell thrust blocks, but even these gave trouble until the lubrication system was wholly and completely redesigned. Since then, we believe, the vessel has run satisfactorily.

The two 33-knot cruisers now building for the United States navy will have the largest power yet installed aboardship, the aggregate being 180,000 h.p. In this case an electric drive will be used. This has some special advantages for warship propulsion, since so much steaming is done at reduced power. The electric drive constitutes a model change gear arrangement, and enables the turbine speed to be kept between economical limits, even when the ship is merely cruising. In the merchant marine, of course, conditions are very different, but even here there have been successful applications of electrical reduction gears, though it is not contended that the efficiency is as high as with mechanical gears, but there are certain offsetting advantages.

At one time there seemed a prospect that the reciprocater would ultimately be banished from sea service, and the figures quoted by Mr. Ward show that the proportion of tonnage equipped with steam reciprocators is being reduced. On the other hand, however, the proportion fitted with internal combustion reciprocators appears to be rapidly increasing.

It is some years since Mr. Ferranti pointed out that the turbine was relatively best in large units: high powers can only be developed by reciprocators by a multiplication of parts. It is therefore natural that the oil-motor has been most in favour for the tramp type of steamer. Nevertheless, it is now being applied to some large passenger ships, and Mr. Ward stated that the New Zealand Shipping Company have ordered from Fairfield a 20,000 ton 18-knot passenger liner, to be driven by Sulzer two-stroke Diesel engines. There will be four propeller shafts, each requiring 3,250 h.p. to drive it. The largest marine oil engines yet ordered are, he states, being built by Messrs. Burmeister & Wain. These will have six double-acting cylinders per shaft, developing 6,750 h.p. It is instructive to compare this figure with the machinery of the Hood, where 36,000 h.p. is developed per shaft by her turbines.

Perhaps the sea-going engineer may not altogether welcome the internal combustion engine. Even the steam reciprocator needed more attention and more frequent overhaul than the turbine, which is, of course, inherently a simpler piece of mechanism. On the other hand, the internal combustion engine materially excels the turbine in the matter of fuel economy. Mr. Ward stated that the best figure yet attained had been realised with the Scott-Still engine, which showed a thermal efficiency of 36 per cent. As yet, a thermal efficiency of 26 per cent. has been barely reached by the steam turbine, though from the published data it could seem that a figure of 30 per cent. is within the bounds of possibility. This, however, is reckoned from the stop valve conditions, and takes no account of boiler losses. Some compensation for this is, however, to be found in the extraordinarily high mechanical efficiency of the turbine, whilst, according to Mr. Ward, the mechanical efficiency of the Scott-Still engine is only 88 per cent. So far no very efficient turbines have been sent to sea, and no doubt the relatively small powers generally required makes it difficult on a commercial basis to rival the figures recorded on land.

The gas turbine shows little sign of progress, and the best thermal efficiency yet achieved is below that recorded with steam turbines. This was perhaps to be expected, since, to quote Mr. Ferranti once again, the characteristic feature of all internal combustion engines is the large amount of negative work involved in the cycle. In the case of a reciprocator this negative work is accomplished very efficiently, but it appears hopeless to expect that any similar level can be attained with rotary compressors, which, though they do beat the reciprocator in output, cannot claim to be anything like as efficient.

The internal combustion engine has, of course, the advantage of dispensing with stokers, but the introduction of oil firing has also made possible considerable stokehold economies in the case of turbine-driven plants, and possibly powdered coal may prove equally effective. As matters stand, the Diesel engine has undoubtedly a higher thermal efficiency, but Mr. Ward points out that such engines require a higher priced oil than is needed for steam raising. Incidentally, it is interesting to note that in the laboratory it has proved practicable to convert coal entirely into oil, but for the present there seems little prospect of this discovery proving commercially valuable.

BRITISH NAVY AIRCRAFT CARRIERS.

A GREAT development has taken place in the use of aircraft for fleet purposes since the establishment of the Royal Naval Air Service, a few years before the war. All nations have recognised this, and their navies now include vessels specially arranged for the carriage and operation of aircraft. It was early perceived that a new factor had come into existence whose effect upon the tactical handling of fleets was likely to be of a revolutionary character. By skilful use of a smoke screen it had been possible hitherto for an enemy to break off an action and escape, but the participation of aircraft in a naval action rendered this manœuvre no longer of service. The use of aircraft enables all the movements of an enemy to be immediately observed and allowed for, and therefore simplifies many of the problems of gunnery control; while aerial reconnaissance will give the admiral in command exact knowledge of the composition and disposition of the enemy's forces long before actual contact between the fleets has been established.

The limitations of the usefulness of aircraft when flown from a shore station are obvious, and so are the difficulties of handling seaplanes from ordinary ships by means of derricks, and of flying these machines from the water in an average seaway. From this has resulted the inception of the aircraft carrier, a vessel specially designed to carry airplanes, and in its further development, to enable them to be flown off and landed on the deck.

The importance of aircraft carriers has been steadily increasing, and they have been honoured by special mention in the Washington Naval Treaty in which they and capital ships are the only types of warships which are defined and limited. In Part IV of that Treaty an aircraft carrier is defined as a ship having a displacement (ex fuel) of above 10,000 tons, designed for the specific and exclusive purpose of carrying aircraft. The maximum displacement of any aircraft-carrying ship is limited to 27,000 tons, except that for provision of conversion of vessels built as capital ships 33,000 tons each is allowed in the case of two ships. The armament of aircratt carriers, as for light cruisers, is limited to guns of a calibre not exceeding 8 in. The combined tonnage of all aircraft carriers possessed by the British Empire must not exceed 135,000. It is also provided that all aircraft carriers building, or in existence on November 12, 1921, can be replaced without regard to age within the total tonnage limit prescribed. This would enable any, or all, of the existing carriers in the British Navy to be scrapped, if desired. Although it is most improbable that full advantage will be taken of this proviso, the generous allowance of total tonnage opens up a fair prospect of naval shipbuilding in this direction.

The earliest aircraft carriers in the British Navy consisted mainly of cross-Channel steamers which were fitted to carry seaplanes; no facilities were provided for the flying off or landing of aeroplanes. Among these ships were the Empress, Engadine, Riviera, Ark Royal, Ben-My-Chree, Vindex and Manxman. Experiments carried out on these vessels, as well as on the Campania and Furious, revealed the possibilities of flying off and landing, and enabled the usefulness of aircraft carriers to be very sensibly augmented. The carriers now on service or completing are the Ark Royal and Pegasus —small ships of the older type, and the Argus, Eagle, Hermes and Furious which are well-equipped up-to-date ships. These four later ships are all illustrated in Figs. 1 to 8 on Plates XXX to XXXII. All these vessels except the Hermes have been converted for their present service. The Hermes was specifically designed for the purpose.

Of these vessels the Argus was described in ENGINEERING on March 28 and April 4, 1919, and is illustrated in Fig. 5, on Plate XXXI. She was launched in July, 1917, and is the only modern type carrier yet actually on service. H.M.S. Furious, originally a cruiser, illustrated in Fig. 4, Plate XXXI, was completed in July, 1917, and is now undergoing a further reconstruction. The Eagle and Hermes have each just completed their trials; the former is illustrated in Figs. 6, 7 and 8, on Plates XXXI and XXXII, and the latter in Figs. 1 to 3, on Plates XXX and XXXI. Particulars of these ships, together with the older carriers are given in the table below:—

Ship.	Length.	Navy List Displacement.	Designed Horse-Power.	Approximate Speed.
				knots.
Ark Royal ..	366	7,080	3,000	11
Pegasus ..	332	3,070	9,500	20½
Argus	565	14,450	20,000	20·2
Hermes ..	598	10,950	40,000	26
Eagle	667	22,790	55,000	25
Furious (before present reconstruction)	786	19,100	90,000	31

For comparison, it may be stated that the only other completed aircraft carriers in existence are the U.S.S. Langley (described and illustrated in our issue of September 14 last), which has a length of 524 ft., a displacement of 19,360 tons and a speed of 14 knots, and the Hosho, of the Imperial Japanese Navy, which was completed in 1922, and has a displacement of 9,500 tons.

The Hermes was designed by the Director of Naval Construction and built at the Naval Yard at Walker-on-Tyne of Messrs. Armstrong, having been laid down in January, 1918, and launched in September, 1919. To the particulars given in the table above may be added: Breadth, 70 ft. below, 90 ft. at flight deck; draught, 18 ft. 9 in.; oil fuel stowage, 2,000 tons. She was considerably delayed in her early stages by important alterations and improvements in design which were made as the result of further experience in mid-1918; and some delay of necessity arose when she was transferred to Devonport Dockyard to complete. As already stated, she is the only aircraft carrier designed and built as such, and has thus escaped the disadvantages inseparable from a reconstructed ship; but the length of time occupied by building and completing her, although unavoidable, is rather apt to be prejudicial to a ship's final efficiency, and it is therefore a matter of congratulation to all concerned that she has undergone a most extensive series of trials with—as we understand—complete success.

Very few particulars of the Hermes have been published; but it is known that she is provided with anti-torpedo blisters and is propelled by twin screw geared Parsons turbines. Her armament consists of six 5·5-in. and some anti-aircraft guns. Like the Eagle she is provided with an "island" unsymmetrically placed on the starboard side of the flight deck, which contains the funnels, mast, fire control and navigating positions. Apart from these rather scanty particulars, little information is available; but it may be of interest to refer to some features which are common to all modern aircraft carriers.

One of the most important peculiarities of an aircraft carrier is the provision of a smooth flight deck on which aircraft can be safely landed. To ensure this it is desirable to reduce all air eddies immediately above that deck to a minimum. To design the upper works of a ship so as to avoid eddying is a rather novel problem for a naval architect, inasmuch as air resistance is of small importance in comparison with that of the under-water form through the water. This problem of the above-water form, although different from the familiar ones associated with the under-water form, resembles them in one respect—it is not completely amenable to mathematical treatment. Model experiments provide the only means to a solution; and it is understood that such experiments are undertaken and the results utilised for the upper works design.

In this connection it should be noted that the flush deck arrangement without funnels, employed on the Argus, and since adopted for the Langley, has not been adhered to in the case of either the Hermes or the Eagle. With such a flush deck horizontal "funnels" are used discharging aft, or near the ship's side below the flight deck. The advantages of such an arrangement for an alighting aircraft are clear inasmuch as the absence of any "island" or superstructure above the flying deck conduces to the suppression of eddies. It appears, however, that a flush deck vessel must be somewhat difficult to navigate; and it is also probable that the large horizontal ducts encroach considerably on valuable space required for other purposes.

A hangar having the maximum accommodation possible is a *sine qua non* in an aircraft carrier. This is necessarily a very long compartment without partitions, which, for reasons connected with water-tight subdivision, must be placed above the water-line. To keep trunks, gearing and leads of various descriptions clear of this hangar is extremely difficult, though absolutely necessary, as it constitutes a danger space from which direct communication to the internals of the ship must be avoided as much as possible. The hangar cannot be sub-divided; but it is understood that fireproof curtains are hung in it at intervals so as to localise the effect of a possible fire outside or within.

As regards the means for handling aircraft, cranes are supplied for embarking or disembarking planes, and lifts for conveying them from the hangar to the flight deck and *vice versa*. The design of these huge lifts must constitute one of the most formidable mechanical difficulties associated with the ship, difficulties which become obvious when the size and area of an areoplane which the lift has to support is remembered. Other features which can be only briefly mentioned here are the provision of adequate workshop accommodation, the safe stowage of large quantities of petrol, the supply of efficient navigation arrangements and last, but not least, the accommodation required for a large complement of officers and men in a ship where natural ventilation and light are peculiarly difficult to obtain.

A paper of considerable interest in this connection was read this spring at the Institution of Naval Architects by Sir Eustace Tennyson d'Eyncourt and Mr. John H. Narbeth, entitled "A Proposed Aircraft-Carrying Mail Steamer."* The type of vessel dealt with therein, although differing from an aircraft carrier designed for naval purposes yet resembles it in many respects; and the paper contains a good description of many of the features common to both types of vessel.

Finally, it will be very evident that the design of a ship from which aircraft can be safely flown presents many difficulties. Even greater ones are encountered by the problem of providing a deck on which such craft can be safely landed. The attention necessarily given to these matters must not be allowed to obscure the old naval problem of securing the best compromise between speed, protection, armament, endurance, and load—which in these ships may be translated into hangar capacity. These difficulties have all had to be surmounted in a very short space of time, and many other features of an entirely novel nature had to be introduced while the aircraft were themselves undergoing a process of rapid development. The success which, it is understood, has attended the trials of these vessels reflects great credit on Sir Eustace Tennyson d'Eyncourt, Director of Naval Construction at the Admiralty, who, together with his staff in the Royal Corps of Naval Constructors, has undertaken the whole of the design work in connection with these ships.

* See ENGINEERING, March 23, 1923, page 359.

STEAMING LANCASHIRE COAL IN VERTICAL GAS RETORTS.

THE installation of vertical gas retorts that was provided at H.M. Fuel Research Station, was meant to serve not merely for the trials of which an account has already been published (*cf.* ENGINEERING, vol. cxv, pages 734, 761 and 811), but also for use on other coals as occasion arose. It will be remembered that the station equipment, coupled with the design of these retorts, enabled coals to be carbonised on a works scale with an accuracy of control over the process and products much exceeding what is possible at an ordinary works, and in fact comparable with that of a laboratory. It was expected that such trials would serve two purposes. On the one hand they would enable industrial gas works to obtain a more accurate knowledge of the coal they use than can be obtained with their own plant. On the other hand, given a sufficiently definite location of the seam from which coals under trial were obtained, they would enable the survey of the country's coal resources which is being made with the help of the station to include particulars of working behaviour and values that hitherto have not been accessible.

Both these purposes can evidently be attained only by a succession of trials on different coals, and the Fuel Research Board has now published a Technical Paper on "The Steaming of Wigan Arley Coal in Vertical Retorts" [H.M. Stationery Office, 9*d.* net.], describing trials made on that coal at the instance of the Preston Gas Company. The previous trials had been made on Durham, South Yorkshire and Lanarkshire coals, and the Arley seam has been proved over the greater part of the South Lancashire coalfield. It is a free burning bituminous coal, applicable alike to gas-making, steam-raising and metallurgical purposes, and is largely used for gas-making in Lancashire. The trials were made on the terms that the quantity of coal necessary for answering the Preston Company's inquiries should be supplied free on rail at Wigan, which was done by the joint contributions of the Preston Gas Company, the Wigan Coal and Iron Company, Limited, and West's Gas Improvement Company, Limited, the Fuel Research Board paying carriage and taking the benefit of the carbonisation products, and in addition purchasing a further 100 tons to extend the trials for their own purposes.

Both consignments were taken from the run of mine output at a particular pit near Wigan, and proximate and ultimate analyses made for each of the six trials showed only slight differences from each other in composition and in calorific value. The laboratory samples on which the analyses were made for each trial were prepared from average samples taken each day from a preliminary sample equal to 5 per cent. of the coal actually charged. In addition to the ordinary analyses low-temperature distillations of samples were also made according to the Gray-King method (*cf.* pages 168 and 169 *ante*), at 600 deg. C. As with the other analyses, the products of distillation of the four samples examined, taken respectively from the first and last parts of each consignment, showed much the same yields; but the low-temperature assay gave from the third sample a much more swollen and porous coke than from any of the others, and a slightly smaller yield.

The plant was the same as in the previous trials, except that two cylinders of relatively small diameter were added for separating and measuring the whole yield of tar and liquor from each test, and the throughput of coal (2¼ tons per retort per day) and method of conducting the tests were also the same. In view of the overheating of the bottom of the retorts, when run without steam, the scheme of experiment included only trials with varying percentages of steam—5 per cent., 10 per cent., 15 per cent. and 20 per cent.—which were intended to be run for two preliminary days to make sure of steady conditions, followed by the test proper over the four next days. In order to conserve coal the change from one percentage of steam to another was made as rapidly as possible, and the retorts watched carefully for 24 hours to make sure that it had been effected before beginning the preliminary two days. The carbonic acid and oxygen in the flue gases were estimated thrice, and in the coal gas twice, per 24 hours; the calorific value of the water gas was taken twice per 24 hours, and that of the coal gas recorded continuously, the recorder being adjusted daily.

The first test was made with 20 per cent. of steam, with the intention of proceeding to the 15 per cent test, but a leak developed in one of the four retorts just after the end of the test, and it was found impossible to work the entire setting with more than 5 per cent. steam. After a test had been accordingly run with that percentage, the defective retort was emptied, its steam supply blanked off, and a certain amount of air allowed to circulate through it while the carbonising tests were begun again and carried through on three retorts. The temperature conditions were consequently somewhat different from those that prevailed with four retorts. The temperature of the gas leaving the retort after carbonisation with 5 per cent. steam was 10 deg. higher with three retorts than with four, and with 20 per cent. steam 58 deg., and similar differences were observed between the temperatures of the upper combustion chambers. It is thought possible, however, that such differences may have been due to small variations in the coal.

A more definite consequence of the use of three retorts was that the unknown quantity of air passing through the empty retort and the alteration that its presence made in the heat conditions of the three working retorts made it impossible to determine in these experiments the thermal efficiency of the carbonising process on the coal in question, as measured by the percentage of heat absorbed in carbonising the coal and carrying off the products at the working temperatures. This was, however, determined in the two tests made with four retorts. With an average temperature in the combustion chambers of about 1,165 deg. C.—about 100 deg. lower than was used in most of the previous experiments—about 31 per cent. of the total heat supplied was taken up by the coal when carbonised with 5 per cent. of steam and 38 per cent. with 20 per cent. of steam.* These figures are lower than were obtained with the Lanarkshire coal, which was carbonised at about the same temperature, but considerably higher than with either the Durham or the Yorkshire coal.

Comparing the results of four retorts with those of three, little difference can be detected in spite of the probable difference in heat conditions. The most notable is a variation of between 2 per cent. and 3 per cent. in the calorific value of gas with 20 per cent. steam, but this is substantially less than irregularities that were found in the earlier tests. In another test the tar seemed to come out about 3 per cent. to 4 per cent. lower than might have been expected from the run of the figures with various percentages of steam, but here again the discrepancy is little more than seems to have occurred in some of the earlier trials, and, as the paper considers possible, may have been due to small differences in the coal. Steaming in three retorts with 20 per cent. gave 4,000 cub. ft. extra gas over steaming with 5 per cent., as against 3,530 cub. ft. extra with four retorts, and the yield of coke decreased by about 14 lb. per 1,000 cub. ft. as against 19 lb., which figures compare with about 7 lb. for the Durham coal and 10½ lb. for the Yorkshire, carbonised, of course, at about 100 deg. higher temperature. In both sets of trials the coal gave considerably more gas than either the Durham or the Lanarkshire, and almost proportionately more heat; but the yield was slightly less than that of the Yorkshire coal, and the amount of heat in

* These figures were obtained as before by deducting from the total heat supplied per hour in water gas and steam the heat carried off in flue gases and dissipated from the retort setting and pre-heater. The heat generated by combustion inside the retort and consequently obtained at the cost of a reduction in the yield of coke was thus left out of account, though strictly it seems that it should be included in calculating a purely thermal efficiency.

the gas gained by increasing the steaming from 5 per cent. to 20 per cent. was only 11 therms per ton of coal, as against about 19 therms gained by the Yorkshire. The calorific values of the gas produced by 5 per cent. steaming were practically the same with four as with three retorts—503 B.Th.U. against 502 B.Th.U. per cubic foot; but from 20 per cent. steam the value was 468 B.Th.U. with four retorts, as against 457 B.Th.U. with three. The analyses of the gases from 20 per cent. steaming in three and four retorts respectively, though similar, show differences in heavy hydrocarbons, carbon monoxide and hydrogen corresponding to differences in calorific value that together work out at 11·4 B.Th.U., as against the observed difference of 11 B.Th.U. The tar in all cases worked out over 10 per cent. higher than either the Durham or the Yorkshire, though lower than the Lanarkshire, but the increase through steaming in four retorts was about the same as the Yorkshire, and in three retorts, though the run of the figures with various percentages of steaming was irregular, was decidedly greater. The ammonia, 24·5 lb. of ammonium sulphate per ton of coal with 5 per cent. steaming and four retorts, and about 23 lb. with three, gained about 4 lb. with 20 per cent. steaming in four retorts and about 5 lb. in three. The run of figures with varying steam seemed to show, as had been observed in the earlier trials, that additional steaming above about 10 per cent. did not produce more ammonia, a fact possibly connected with a rise of the temperature of gas in the ascension pipe, which was observed in the previous trials as well as in these.

The ash estimated on an approximate average of the first consignment showed the unusually low fusing-point of 1,090 deg. C., following on a softening-point of 1,080 deg. As the report points out, there is no evidence, and it is unlikely, that all coal from the Arley seam has such ash. Perhaps it is as well that the percentage of ash in the six samples analysed was moderately low—5·81 per cent. to 7·68 per cent. on the dry coal. The breeze (coke passing $\frac{7}{8}$ in. sieve) varied somewhat irregularly from 1·14 to 1·53 cwt. per ton of coal, as against 1·78 to 2·24 for the Yorkshire, and over 2 for the Durham and Lanarkshire.

On the figures of the report the yield with 5 per cent. steaming and the relative effect of 20 per cent. steaming, may be summed up in round figures by the statement that with 5 per cent. steaming a ton of Wigan Arley coal gives about 16,000 cub. ft. of gas with an increase of 25 per cent. in volume at the higher rate of steaming, a calorific value of about 500 B.Th.U. with a decrease of 9 per cent. and a total heat of 80 therms with an increase of 13 per cent., in addition to 13½ lb. of tar with an increase of 8 per cent. and 23½ lb. of sulphate of ammonia with an increase of 22 per cent.

The uncoloured candour with which the results are stated suggests certain general observations on the trials. It is quite clear that this method of exposition gives a far greater value to the collection of data that the Board has begun to accumulate than a series of reports would have that set out only positive and successful results. The advantage of having figures obtained by methods of unusual accuracy is none the less because the experimental accuracy seems to be substantially higher than the regularity of the material or of the changes that go on during carbonisation. On the contrary, it eliminates avoidable sources of error, and enables the cause of apparent discrepancies to be sought in a more restricted number of directions and with a proportionately greater chance of success than if figures for the factors now controllable with the Station plant and methods were, as in other works they must be, themselves open to doubt. The present tests, like their predecessors, show a number of possible sources of variation in results that it is to be hoped may ultimately be cleared up:—the effect of the lining of scurf (the age of which is recorded for each of the present tests) on the actual temperature of carbonisation, the circumstances that determine the sometimes remarkable differences of temperatures at various heights in the retorts, the distribution of these temperatures in the body of the charge, even the relation of samples to bulk. These are some of the matters on which light remains to be thrown. The candid accumulation of data such as are given here, with such extensions as each set of trials may suggest, seems to afford the most hopeful prospect of arriving ultimately at the required general knowledge of how processes of carbonisation may be best applied. In the meantime each set of such data gives working information for those who use the coal in question which has practical and immediate value, such as it is understood the Preston Gas Company has derived from the present results.

LOCOMOTIVE CONNECTING ROD FAILURES.

Practically a year ago, under the above title, we discussed the report by Lieut.-Col. G. Mount on the Cheadle Hulme accident on the London and North Western Railway, in which a connecting rod failed and ruptured the boiler plating. The report has just been issued of a very similar accident on the same system, which occurred on May 31 last at Betley-road, near Crewe. In this instance the report is drawn up by Major G. L. Hall, and although the circumstances of the failure were similar in the two cases we are pleased to note that the suggestion is not now advanced that the failure was due to water in the cylinders.

The rods of the engine in question were of nickel steel and the valve gear was of the Joy type, which requires the provision in the rod of a transverse hole for the jack link pin, at which point the rod is enlarged. As on the former occasion, the rod broke just on the small end side of this pin hole boss. In the last instance a flaw appears to have started on the underside of the rod and to have worked its way inwards until, on the date of the accident, it was too weak to stand what may have been the reversal of stress caused by suddenly shutting the regulator when travelling at between 65 and 70 m.p.h. Subsequent examination at the National Physical Laboratory revealed slightly too high a percentage of phosphorus, with signs of some overheating resulting in a crystalline texture. These facts alone are hardly considered by Major Hall to have been sufficient to cause the failure, and there appears to be nothing definite to which the origin of the crack can be traced. Although it had the appearance of an old flaw, it had not been discovered in the frequent shed inspections, though these are seldom carried out under easy conditions. At the same time little is known as to the rapidity with which such a crack may develop. A point of interest is the statement by the drawing office staff that these rods are designed for a factor of safety of between 5 and 6, but if this is actually the case, the metal would have had to be very bad indeed to fail, whereas this was not really so. It seems to be more probable that the approximate methods of estimating the stresses do not satisfy all the intricacies of the case of the Joy gear, and it is possible that insufficient allowance has been made for the additional strain put on the rod by driving the jack link off it under severe working conditions; with the result that these rods may be stressed much nearer the safe limit than is supposed. This would seem to explain the figures given in our previous article, while Major Hall's more recent figures also support the idea. Between May, 1922 and May, 1923, 91 rods were condemned on the London and North Western, of which 80 were Joy rods, and of these in 77 cases the failure was in the neighbourhood of the jack link pin hole. Only 15 of these rods were nickel steel and the rest mild steel.

Previous cases have pointed to the necessity for every possible care being exercised in the treatment during repairs of the nickel steel rods, and definite regulations are in force regarding them. The difficulty, however, of correctly estimating the stresses in these rods will be evident when it is considered that the piston speed is 1,400 ft. per minute, that the inclination of the quadrant is varied constantly, that the effect of fitting on a number of surfaces has to be taken into account, superimposed upon which may be sudden reversals of stress due to steam being shut off and the engine being worked by the following train. It may be that under such severe conditions the curve on which the metal sweeps from the boss out into the tapering rod actually amounts to a modification of a notch, and that sufficient attention has not been centred upon this. An increase in the diameter of the boss would not by itself improve matters. Under the circumstances it is as well probably that some other form of gear is to be adopted, although the Joy gear has proved satisfactory for a wide range of service.

THE LATE MR. H. A. IVATT.

An engineer who has left a decided mark upon locomotive developments has passed from us in the regretted death on Thursday last of Mr. H. A. Ivatt. Mr. Ivatt will always be remembered as "of the Great Northern," since it was on that railway that he had the opportunity which brought his name prominently forward. He was another example of the success which has so often followed training at Crewe during the days of John Ramsbottom and F. W. Webb.

Mr. Henry Arthur Ivatt was 72 at the time of his death. He was the son of the Rev. A. W. Ivatt, rector of Coveney-cum-Maney, Cambridgeshire, and received his early education at Liverpool College. At the age of 17 he entered the Crewe works of the London and North-Western Railway Company as an apprentice for four years. At the close of this training, first under Mr. John Ramsbottom and subsequently Mr. F. W. Webb, Mr. Ivatt served as a fireman for twelve months on all classes of traffic, and afterwards had six months on outdoor duty in the traffic department, thus securing a view of the other side of the picture, in the form of the requirements of the traffic department as distinct from the supply of power by the "loco," which latter is, unfortunately, often all that officials in the mechanical department are familiar with. We need not go into detail with regard to Mr. Ivatt's work of the years immediately following. After working at Stafford as assistant foreman of the running shed he was given charge, at the close of 1874, of Holyhead, being, in 1877, transferred to the charge of the Chester district. The latter position he retained only a short while, relinquishing his connection with the "North-Western" on appointment to the charge of the Cork district of the Great Southern and Western Railway of Ireland. In 1882 he was transferred to Inchicore as assistant locomotive superintendent, and was promoted to the position of locomotive superintendent in 1886. This position he retained for ten years, when in 1896 he moved to Doncaster to take up the duties of locomotive superintendent to the Great Northern Railway, following upon the death of Mr. Patrick Stirling.

Two years previous to Mr. Ivatt's transfer to the Great Southern and Western Railway another Crewe man had accepted an appointment on that line. We refer to Mr. (now Sir) J. A. F. Aspinall, who first went to Inchicore in 1875 as works manager under Mr. A. McDonnell. Of the same age, Mr. Aspinall and Mr. Ivatt had much in common, and the connection which their duties in Ireland brought about had noticeable results at a later date in their professional career, during which they kept closely in touch with one another. It may be noticed that Mr. Ivatt was appointed assistant to Mr. Aspinall when the latter held the position of locomotive superintendent, and succeeded to the chief position on Mr. Aspinall leaving for the Lancashire and Yorkshire Railway in 1886. During Mr. Ivatt's Doncaster days the intimacy in professional work was resumed, and instances of experimental work on parallel but distinct lines resulted.

By the time that Mr. Ivatt reached Doncaster, Mr. Aspinall's policy had been already defined, and he was fortunate in being in charge of model shops of his own planning. At Doncaster the situation was different. For many years the Great Northern had been noted for the Stirling 8-ft. singles, and its reputation rested with moderately light expresses. It was a turning point in the history of our English trunk lines. The famous single wheelers on most of the railways were falling behind the times, not being capable of dealing unaided with the increasing train weights which followed upon the demand for

greater comfort in travel. Competition in facilities was active, and the minds of all superintendents were engaged on the task of further developing the power of the locomotive. The limit of the Stirling singles was reached in what was known as the "1003" class, while the Great Northern also possessed six-wheeled inside cylinder engines with single and also with four coupled-driving wheels. At the time the only main line bogie engines on the railway were the Stirling 8-footers.

About the first work which Mr. Ivatt took in hand was the design of a four-coupled bogie passenger engine, and the first to be built, No. 400, was the forerunner of a very useful class. This design was comparatively simple and straightforward, as the demand at the time for more power was pressing, and it was not advisable to introduce anything of which the success could not be directly assured. It was just at the commencement of the large boiler era, and had it been realised then, as clearly as it is now, how important is the steaming capacity of a locomotive, it is probable that No. 400 and its sisters would have had larger boilers.

The true influence of this factor on locomotive power was not then recognised; all the older school had built famous engines with what we now consider to be small boilers, and the younger men were only just beginning to feel their way in another direction. However, it was not long before other classes followed No. 400, similar, but with larger boilers, and much better capable of handling the fast main line traffic without assistance. Pilot working began to disappear, and the 1321 class soon acquired an excellent reputation. Mr. Ivatt, however, did not immediately abandon single wheelers, for he rebuilt some of the Stirling singles with larger boilers and also introduced a new 7-ft. 6-in. single bogie inside cylinder class with more than 200 sq. ft. of heating surface over that provided in the last big Stirling engines. These did very good work, but the trend was away from this type, and with a view to securing greater boiler power Mr. Ivatt turned to a design then becoming well established in America as the "Atlantic" type. The engine No. 990, turned out of the Doncaster shops in 1898 to Mr. Ivatt's design, was a radical departure from previous types in England. It had outside cylinders, return coupling rods, and outside frames at the trailing end, a combination worked out in a very effective manner. It is interesting to note that at the same time the Horwich works, under Mr. Aspinall, were busy on a class with similar wheel arrangement, but with inside cylinders. Mr. Aspinall as a matter of fact produced a more "advanced" boiler, Mr. Ivatt moving, if anything, at first a little cautiously in boiler design.

This was subsequently to be remedied, for as it became even more apparent that boiler capacity was a deciding factor, Mr. Ivatt again pioneered in this country with a design of wide fire-box engine, by which means he was able to secure, as had been by then demonstrated to be practicable in the United States, ample grate area for a large heating surface, combined with moderate length of grate to be fired. The wide fire-box engines of the 251 class of the Great Northern were probably Mr. Ivatt's best engines, though he introduced many other designs, all characterised by liberal boiler capacity, and distinct in other ways. He produced a number of tank engines which greatly added to the railways' ability to meet the increasing demands of suburban and other services. Among the more noted were his 4-4-2 tanks, 0-6-2 and 0-8-2 engines. All were typically neat, and proved themselves as powerful in service as their appearance suggested them to be. It is unnecessary to detail all the designs for which Mr. Ivatt's *regime* was responsible. He was perhaps fortunate in reaching Doncaster just at the time when on all lines a break had to be made with the immediate past. Mr. Ivatt would have been the first to admit that some of his experimental work—he was at one time interested in compounding, and in four-cylinder engines—had not led where it was hoped it might, and was consequently not followed up. This is inevitably the case to some extent in all classes of engineering. The net result of his work was undoubtedly to place the Great Northern in a position second to none in the country as regards its capacity to handle modern traffic, and as the introducer of the wide firebox and the Atlantic type he will take a definite position in our locomotive history. It may not be out of place to mention that an adaptation of the design of trailing end used on No. 990 was almost immediately produced in connection with Atlantic engines for the Chicago and North-Western Railway in the United States. This was the first class in that country to employ outside bearings for the trailing end, a practice since considerably extended.

Disliking anything in the way of ostentation, and retiring in nature, Mr. Ivatt was not very

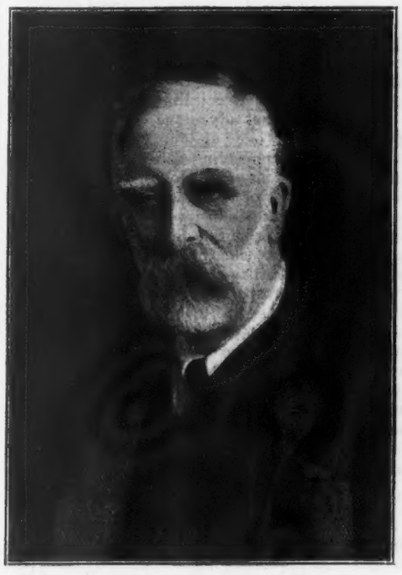


Photo: Elliott and Fry.

THE LATE MR. H. A. IVATT.

prominent in technical circles. He was a member of the Institution of Civil Engineers, and a Member of Council and Vice-President of the Institution of Mechanical Engineers. He was extremely modest and deprecated any comparison of his work with that of his famous predecessor—a point which made the discussion of locomotive development on the Great Northern at a critical epoch, a matter of some difficulty if his approval was to be secured. He was extremely courteous, and his relations with his men, and especially the senior drivers, were excellent. He took a great interest in their work and performances, and did much to encourage their improvement classes, &c.

THE MOTOR EXHIBITION AT OLYMPIA.

IN an industry which depends for its prosperity upon the amount of appreciation which its work receives from the public, the annual exhibition of new design proposals and improvements in manufacture is essential to the continued activity of the firms engaged in it. These exhibitions, of which the seventeenth was opened at Olympia this morning, therefore serve as an index of the progress of the industry. The changes effected to obtain improved running with reduced fuel usage are open to the criticism of all, and those manufacturers who bring out constructions that appeal may measure their success by the degree of meeting public requirements. When the differences in outlook of America and Great Britain in motor car production and use is reviewed, it can only be taken as a fact that there must be extensive propaganda work done in this country before we may be considered as a motor car using nation. There is one car to every nine people in the United States while in Great Britain the proportion is only one to a hundred. Mass production has made possible very great reductions in costs in America, and the prices have been brought down to a level such that workmen can afford to be purchasers. Much may be done here to reduce the costs by the same methods, but the different outlook and nature of the two peoples must be given some consideration if success is to be secured. Whenever it is at all possible, the British people will demand a British made article, having those attributes which have made our reputation throughout the world. If there is no competition in any particular field, such as that of the cheap car, the prospective buyer is forced to decide between the nearest approach to a suitable machine made at home and an article made abroad which is much cheaper. There are signs, however, that our manufacturers are not all content to deal only with a limited number of clients who can afford to pay high prices for luxury. Some of them are reducing costs by standardising the components of their cars and improving their works methods. These deserve all the support that can be given them, their products have been subjected to actual tests by many users on the roads, and they have shown up well. Prices have been dropped, and with increased output further changes may be anticipated. Service conditions have been improved, and spare parts may be obtained with less difficulty than was formerly the case.

That there is a growing trade in motor cars is evidenced by the statistics prepared by the Ministry of Transport. On August 31 of this year there were 383,525 motor cars taxed on the basis of horse-power, which compares favourably with the figure of 314,769 for the same date of last year. The class described as motor hackneys grew from 77,614 to 85,965 in the same period. Now that prices have been diminished and running costs are reduced by the fall on the price of petrol to lower than the pre-war figure, a continuous extension may be anticipated. Every cost, except the tax, has been cut down, and prices are now such that many who were formerly devoted to motor cycling may become purchasers of the very cheap small power models.

The value of the export trade must be appreciated to a greater extent by the manufacturers. In this field the vehicles that best meet the conditions may be expected to find growing use. In this sphere also the competition of cheap articles of non-British manufacture makes progress difficult, especially with the lower priced vehicles. There is a fair amount of business in the better class machines, but it will admit of considerable extension before any satisfaction may be had from the figures. As far as foreign competition in the home market is concerned there is little, if any, reason for its existence. With the varied equipment of substantial design that is the characteristic of the home product surely the most fastidious and exacting purchasers can find some machine of British design and manufacture which will meet their requirements. For those people, if they can forget what must be merely a prejudice, the show of 1923 must be a revelation in what our motor manufacturers can supply to meet their demands. This exhibition, arranged by the Society of Motor Manufacturers and Traders, enables a complete survey of the many refinements introduced into the mechanism of a high-class car and the improvements in comfortable travel afforded in vehicles where the magnitude of the first cost is not such a vital consideration. In this smaller but more exacting market British products have always, and do still, set a standard which is rarely, if ever, surpassed by any foreign makers.

In a preliminary survey of the machines put before the public at Olympia, there are many changes in outlook of the designers which are impressed upon the visitor. These we may consider now and leave for later the critical description of some of the leading examples. The motor car has so many components, engine, chassis, gears, springing, brakes, clutches, ignition systems, &c., in each of which variety is possible that there is ample scope for the ideas of any individual designer. The most popular combination is a four-cylinder engine having detachable cylinder heads, side by side valves, thermo-syphon cooling and magneto ignition and associated with a cone clutch, a four-speed gear and a final drive made in the form known as spiral bevel. The greater number of

the chassis are provided with semi-elliptical springs and the wheels commonly favoured have steel spokes. From this it may be gathered that the popular outlook is not very different from that of former years except perhaps that the three-speed gear has been relegated to second place in popularity. There is for some of the components, however, a narrowed margin between the numbers of cars fitted with the most popular form and that which occupies the second position.

Of the engines shown at Olympia, three-quarters have four cylinders and about one-fifth are of six cylinders. The remaining small number is divided between engines of two and eight cylinders. It may be judged from this that the public has decided that a four-cylinder engine gives every satisfaction in smooth running, and a greater number is only resorted to when expense is not a pressing consideration. The advocacy of higher speeds of running for engines and higher compression pressures has had a marked effect in increasing the number of engines fitted with overhead valves, and in the show over one-third of the engines are provided with inlet and exhaust arrangements of that character. The sleeve valve has not made the headway that many anticipated for it, and this interesting endeavour to obtain easy and silent operation combined with rapid and large openings is only fitted to some 6 per cent. of the engines of the standard cars in the show. The advantages of electric starting are so marked that it is not surprising to find over 90 per cent. of the cars exhibited have that useful appliance fitted.

The four-speed gear has attained ascendancy, as has already been stated, but the ratio of its application to that of the three-speed type, which had great popularity in earlier days, is only five to four, while other arrangements only amount to one-fiftieth of the total. Perhaps the most outstanding development of the year is in the number of cars to which four-wheel brakes have been fitted. Already there are 28½ per cent. of all the models manufactured so fitted, if the machines on show at Olympia are to be taken as the index. The indication of the desire for increased security when sudden stoppages are required has been met, and many of the designs reflect greatly to the credit of the manufacturers. Applying brakes to wheels which must be capable of movement in turning was not devoid of difficulty, but complete and effective solutions have already been found, and some of these we hope to illustrate when dealing with some of the individual exhibits.

(To be continued.)

NOTES.

Auxiliary Machinery for Diesel-Engined Vessels.

In a paper on this subject by Mr. Robert Love, read at a meeting of the Institution of Engineers and Shipbuilders in Scotland on Tuesday last, the relative advantages of steam and electric-driven auxiliaries were reviewed. The electrically-driven plant now available for marine work was as reliable in service and as easily maintained at maximum efficiency as the best type of steam plant. Tables of costs of operating were given which showed results in favour of the electric system. In the case of a ship of 2,000 tons deadweight capacity running at 10·5 knots —a saving of 1,890*l.* in fuel costs was shown, while a sum of 3,098*l.* was given as the saving for a vessel of five times that deadweight capacity but running at the same speed. The use of steam auxiliaries was attended with a high fuel cost, but the general adoption of the electric system had been hindered by the high initial cost of the plant. For the electric system it was suggested that not less than three Diesel-driven generators should be used to supply the auxiliaries, and that each should be capable of dealing with one-half of the maximum demand under manœuvring conditions. The requirements were generally met with combinations of cylinder units of standard sizes. As an example, the Beardmore-Tosi auxiliary engine was standardised in sets of from two to six cylinders of 45 h.p. per cylinder at 250 r.p.m. to 275 r.p.m., and 60 h.p. at from 210 r.p.m. to 230 r.p.m. The advantages in low cost of running and upkeep which were obtainable if low speeds were used were emphasised, and the requirements of the individual items among the auxiliary plant were detailed and suggestions made for their arrangement for satisfactory operation.

Automobile Engineering.

There is a satisfactory impression current that our motor-car trade is showing signs of revival, and those who are concerned in it and attended the fourth annual dinner of the Institution of Automobile Engineers, on the 24th ult., certainly showed no signs of any connection with a depressed industry. In contradistinction from the procedure of the larger and older engineering institutions, it is the practice to invite ladies to this dinner, and this feature probably has something to do with its success as a social function. In the present instance, it had the additional advantage of leading to the representation of one of our new institutions —the Women's Engineering Society, by the President, Lady Parsons. Sir John Dewrance, who proposed the toast of the Institution, pointed out that the automobile industry at the present day employed as much labour as did the whole engineering industry at the time he entered it. This was a striking way of calling attention to the importance of a trade, the prosperity of which is a matter of national importance. So much does the maximum possible development of motor-car building in this country depend on the standardisation of detail parts that we are always glad to hear the question raised, and it was satisfactory to hear from Mr. H. G. Burford, the President of the Institution, that in the last few weeks the number of types of windscreen fittings had been reduced from 70 to 7, and the number of wheel types from 100 to 24.

Lloyd's Register of Shipping.

Attention is again called to the continued depression in the shipbuilding industry, which still shows no signs of an impending improvement, by the report just issued by Lloyd's Register of Shipping dealing with the Society's activities during the year ended June 30 last. In comparison with the tonnage classed in the previous year, a reduction of 36 per cent. has to be recorded in the tonnage classed by the Society in 1922–23, for which period the figure was 1,616,225 tons gross, comprised in 429 vessels. Plans for 424 vessels of 1,065,850 tons in the aggregate, however, were passed during the year covered by the report, and this figure is higher than that for the preceding twelve months, although it by no means follows that all these vessels will actually be laid down; in any case, the figures are far below the average for several years prior to the war. The largest of the vessels built during the year and classed by the Society, was the Cunard liner Franconia, full particulars of which will be found on pages 651 and 680 of our last volume. This vessel is of 20,158 gross tons, but 7 others exceed 15,000 tons and 10 more range from 10,000 tons to 14,000 tons. The total number of vessels of 10,000 tons and over built and classed during the year was therefore 18, whereas the corresponding number for the year 1921–22 was 32. Steam turbines have been fitted in 74 new vessels, making 603,037 tons, and 15 of these ships are of more than 10,000 tons each. With one exception, all vessels of 15,000 tons and over are propelled by turbines, and in all cases some form of reduction gearing is employed. The gearing is mostly of the double-reduction type, but in one vessel, the Kamoi, of 10,222 tons, the turbo-electric system of propulsion is employed. Vessels built to class during the year and fitted with oil engines for propulsion numbered 14, and had an aggregate gross tonnage of 164,665. At the present time, 175 marine Diesel engines, with a total brake horse-power of about 246,000, are in course of construction under the superintendence of the Society's surveyors. It is interesting to note that more than half the total number of these engines, 92 to be exact, are of the two-stroke cycle type; what proportion these two-cycle engines represent of the total horse-power given above is not mentioned. Two of the engines building are of the six-cylinder, four-cycle, double-acting type, each developing 6,750 b.h.p. These engines, which are under construction at Messrs. Burmeister and Wain's works, Copenhagen, have cylinders 33 in. in diameter, with a piston stroke of 59 in., the cylinder diameter being 3 in. larger than that of any other Diesel engine fitted in a vessel, and the horse-power is also greater. The engines are intended for a twin-screw passenger vessel being built by Messrs. Armstrong, Whitworth and Co., Limited, for the Swedish-American Line. Another double-acting Diesel engine of the three-cylinder, two-cycle type is under construction by the North British Diesel Engine Works, Limited, at Glasgow. The report refers to the favourable reception accorded to the Society's Revised Rules for the Construction and Classification of Steel Vessels, and mentions that the date for compulsory application of the rules has been postponed until January next. The foreign work of the Society and other branches of its activities are also dealt with in the report, which contains much material of interest to shipping and shipbuilding concerns in all parts of the world.

NOTES ON NEW BOOKS.

The popularisation of cut gears is largely attributable to American engineers, possibly because skilled foundry men are more scarce in the United States than in this country. For many years British-made machine tools were as a consequence equipped with cast gears, whilst cut teeth were in almost universal use for similar machines made in America. To-day, the cut gear is universally adopted for all high-class machinery. The range of sizes now available is extraordinary, and at least one maker is prepared to furnish double helical wheels for ship propulsion up to 18 ft. in diameter by 7 ft. width of face. These remarkable developments have reawakened interest both in tooth geometry and in the methods and machines used in gear cutting. The whole subject is well set forth in the "*Principles and Practice of Gear Wheel Cutting*," a book by Mr. G. W. Burley, B.Sc., who is head of the mechanical engineering department of the Victoria Jubilee Technical Institute at Bombay. The book deals both with the theoretical and practical side of the subject and the text is supplemented by 347 illustrations. Numerous tables for facilitating calculation are given in the appendix. These do not merely economise time, but greatly diminish the possibility of arithmetical errors. The work is published by Messrs. Scott, Greenwood and Son, London, at 25*s.* net.

The attempts to introduce a metric screw gauge into Germany date from 1876. But the Whitworth gauge of 1841 was firmly rooted, and though the British Association gauge, the Thury gauge, the metric gauge of the Zürich Congress of 1898, and the S.I. metric gauge later found many adherents, by 1911, when Schlesinger's efforts for one international, or in the first instance national, gauge received wide support in Germany, 70 per cent. of the works were still adhering to the Whitworth gauge, 14 per cent. to the S.I. system (with a thread angle of 60 deg.) and the rest to other systems, of which 11 were, and are still, in extensive use. The war interrupted the unification work. By 1922 the Normal Gauge Committees of the German Industry had, however, brought their work to a certain completion. The outcome of their deliberations is the "*Normung der Gewinde-Systeme*," by Dr. Ing. G. Schlesinger, Professor at the Charlottenburg Technical High School. The pamphlet, of 80 pages, which is published by the Normenausschuss der Deutschen Industrie (Dinorm), describes and illustrates the screw threads of various types and their tolerances. It is hoped that only the Whitworth gauge and the metric (S.I.) gauge will survive; that would reduce the numbers of various tools and standards to one-fourth of their present figure.

The advance of mathematics has been to no small extent dependent upon the devising of improved notations. How our ancestors managed to work sums in long division with Roman numerals is a mystery to most of us to-day. Again, on the revival of learning a long period elapsed before a concise method of writing powers of quantities was devised. Till this was done the work of the mathematician was hampered by the mere bulk of his expressions much as that of the computer was before the invention of logarithms. In the case of geometry, matters are fairly simple, so long as we stick to two dimensions, but with three we often get extremely long and involved expressions, the mere copying down of which necessitates minute attention if error is to be avoided. The doctrine of relativity has introduced time as a fourth dimension, and this has involved a corresponding increase of complexity. To diminish this and to render the mathematical expressions more manageable the tensor notation

has been introduced, and this forms the subject of an elementary treatise by Dr. W. F. Sheppard, entitled "*From Determinant to Tensor.*" The work is published at the Clarendon Press, Oxford, the price of issue being 8*s.* 6*d.* net. The author requires from his readers only an elementary knowledge of algebra; but, of course, there never has been, nor will be, a royal road to mathematics, and the reader must be prepared to expend considerable time and thought if he is to master the text.

"There are persons who think, or profess to think, that perfection in ship designing has been achieved. As a matter of fact there has been no important improvement in the design of hulls of vessels since the ship of the paleolithic stone age . . . Some people scoff at the bare mention of Noah's Ark, but there is no getting away from the fact that the story of the Ark was written thousands of years ago; and note the proportions given in the Bible . . . If we doubt the Divine source of Noah's instructions we are forced to admit that in that remote period in which the scriptures were written, the science of shipbuilding were so far advanced that someone gave elaborate details for the building of the Ark, and that these details were so just and scientific that Mr. Brunel adopted them in his design for the Great Eastern . . . It does not by any means follow that something may not be thought of that will revolutionise the designs at present followed in shipbuilding, and if you—Reader—have never attempted to design a ship, you are as likely to be successful as anyone else." This extract, with its encouraging conclusion, speaks itself for the seventh edition (1923) of "*Sexton's Pocket Book on Boiler-making, Shipbuilding, and the Steel and Iron Trades in General,*" as revised by Mr. P. W. McGuire, M.I.Mar.E., and published by Messrs. E. and F. N. Spon, Limited, at the price of 6*s.* net.

BOOKS RECEIVED.

United States Bureau of Mines. Bulletin No. 219. *Explosives, Their Materials, Constitution and Analysis.* By C. A. Taylor and W. H. Rinkenbach. [Price 20 cents.] Technical Paper No. 283. *Tests of Low Grade and Complex Ores in Colorado.* By W. H. Coghill and C. O. Anderson. [Price 10 cents.] No. 294. *Progress of Investigations on Liquid-Oxygen Explosives.* By S. P. Howell and others. [Price 15 cents.] No. 315. *Comparative Tests of By-Product Coke and other Fuels for House Heating Boilers.* By H. Kreisinger and others. [Price 5 cents.] No. 321. *Anhydrous Aluminium Chloride.* By O. C. Ralston. [Price 5 cents.] No. 326. *Fires in Steamship Bunker and Cargo Coal.* By H. H. Stock. [Price 10 cents.] No. 328. *The Motor Gasoline Surveys of* 1920 *and* 1921. By N. A. C. Smith. [Price 5 cents.] No. 333. *Permissible Explosives, Mining Equipment and Apparatus Approved prior to January* 1, 1923. By S. P. Howell and others. [Price 5 cents.] No. 334. *Mine Rescue Standards, A Tentative Study.* [Price 5 cents.] Washington: Government Printing Office.

Flying. By Major W. T. Blake, F.R.G.S. London: George Allen and Unwin, Limited. [Price 6*s.* net.]

The Advancement of Science, 1923. *Addresses Delivered at the Ninety-First Annual Meeting of the British Association.* London: John Murray. [Price 6*s.* net.]

Aeronautical Research Committee. Reports and Memoranda No. 823. *Description of Lift, Vertical Force and Drag Balances for the Roof of the Duplex Wind Tunnel.* By T. H. Fewster. [Price 9½*d.* post free.] No. 827. *The Prediction of the Resistance of Rigid Airship R* 33. By R. A. Frazer and A. G. Gadd. [Price 1*s.* 3½*d.* post free.] No. 828. *A Continuous Rotation Balance for the Measurement of* L *at Small Rates of Roll.* By E. F. Relf and T. Lavender. [Price 4½*d.* post free.] No. 835. *Tests of Four Slotted Aerofoils supplied by Messrs. Handley-Page, Limited.* By F. B. Bradfield. [Price 9½*d.* post free.] London: His Majesty's Stationery Office.

The Chemical Resistance of Engineering Materials. By Marston L. Hamlin and Francis M. Turner, Junior. New York: The Chemical Catalogue Company, Inc.

Discours de la Nature de L'Air de la Végétation des Plantes. Nouvelle Découverte Touchant la Vue. By Edme Mariotte. Paris: Gauthier-Villars et Cie. [Price 3 francs.]

Commissario dell' Aeronautica Intendenza Generale. No. 3. *Notiziario di Aeronautica. Note Techniche de Aeronautico.* Rome: Tipografia della R. Accademia Nazionale dei Lincei.

Radio and High Frequency Currents. By E. T. Larner. London: Crosby Lockwood and Son. [Price 3*s.* 6*d.* net.]

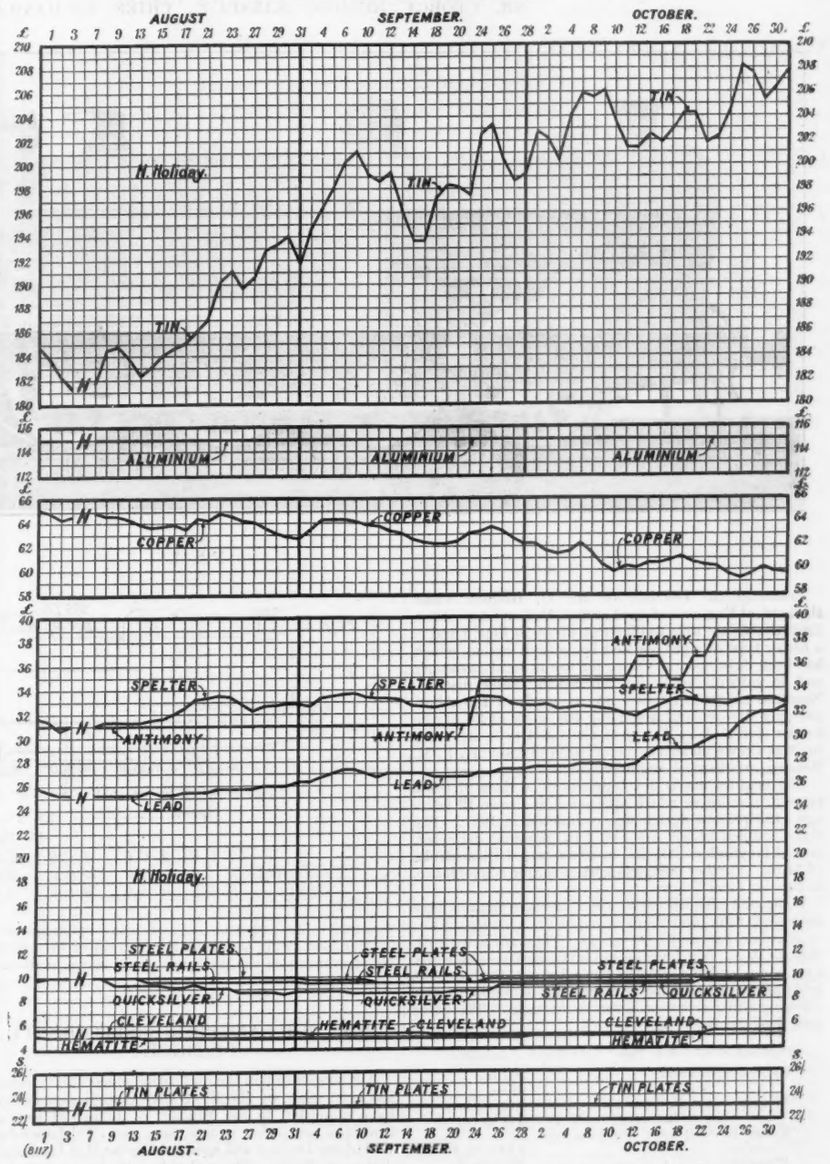
Concrete Roads and Their Construction. Second edition. London: Concrete Publications, Limited. [Price 5*s.* net.]

Engineering Kinematics. By Wm. Griswold Smith, M.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

The late Dr. John Edward Stead.—At the time of going to press we learn with great regret the death of Dr. John Edward Stead, D.Sc., D.Met., F.R.S., the well-known scientist, who was president of the Iron and Steel Institute during the years 1920–22. We shall give a review of his distinguished career in our next issue.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

Gasoline as a Refrigerant.—Experiments, attended by some success, have been made in the use of gasoline as a refrigerating agent instead of ammonia. A freezing plant at the Bartlesville station, in Oklahoma, of the United States Bureau of Mines, has been run experimentally with volatile gasoline with a view to eliminating, if possible, the expensive equipment necessary for use with ammonia. The results are considered to be of considerable promise, especially where natural-gas gasoline is available.

Information on Aeronautics.—The Direzione Generale di Aeronautica, Rome (the Italian Air Service) issues monthly a review in Italian ("Notiziario di Aeronautica") giving information on the science of aeronautics, the sections covering military and naval service, commercial flying, aerotechnics and sundry data, and showing the progress made in all the various branches throughout the world. No. 3, for September, is now available, and contains notes, statistical data and abstracts of interest to manufacturers and pilots. A separate appendix to No. 3 reproduce technical notes on "The Temperature Distribution in Cylinder and Piston of an Aeroplane Engine," "On the Heat Treatment of Duralumin Sand Castings", and other papers read at the recent aerial conference in London.

The Institution of Electrical Engineers.—The joint meeting with this Institution and the British Section of the Société des Ingénieurs Civils de France, which was to have been held on Thursday, November 15, has been postponed to Thursday, November 22, when a paper by M. Bachellery entitled "The Electrification of the Midi Railway" will be read and discussed.

0-8-4 TANK LOCOMOTIVE; LONDON, MIDLAND AND SCOTTISH RAILWAY.

MR. GEORGE HUGHES, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

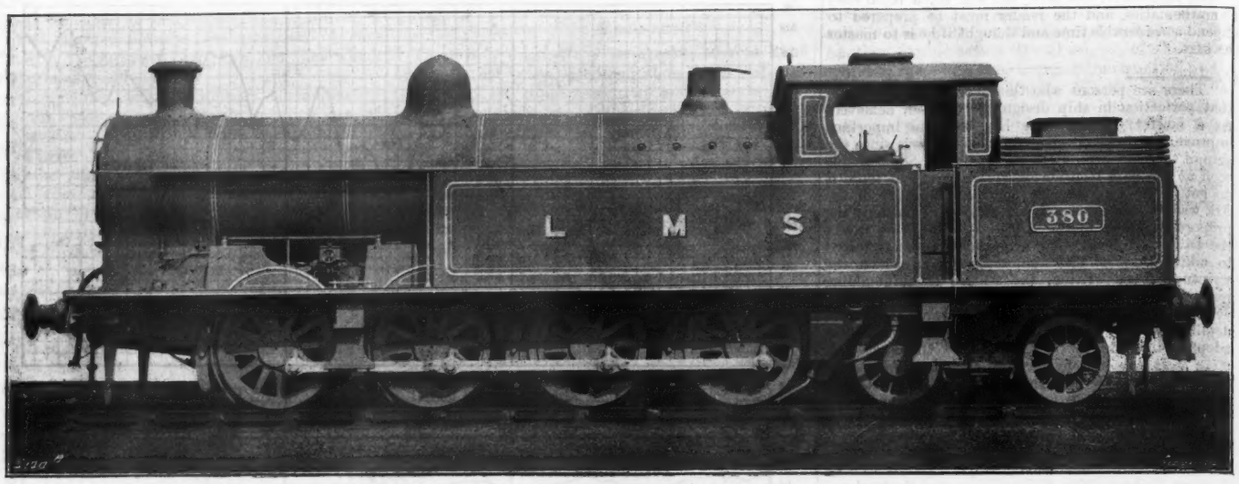


FIG. 1.

THROUGH the courtesy of Mr. G. Hughes, Chief Mechanical Engineer of the London, Midland & Scottish Railway, we are able to illustrate above in Figs. 1 and 2, a heavy type of eight coupled bogie tank engine, which has been developed at Crewe for use in local passenger and in mineral traffic in the South Wales district. Nineteen of these engines are at work in the Abergavenny district and are doing the work of 30 of the former side-tanks. Thirty of the 0-8-4 type are being built at Crewe under the supervision of Capt. H. P. M. Beames, mechanical engineer.

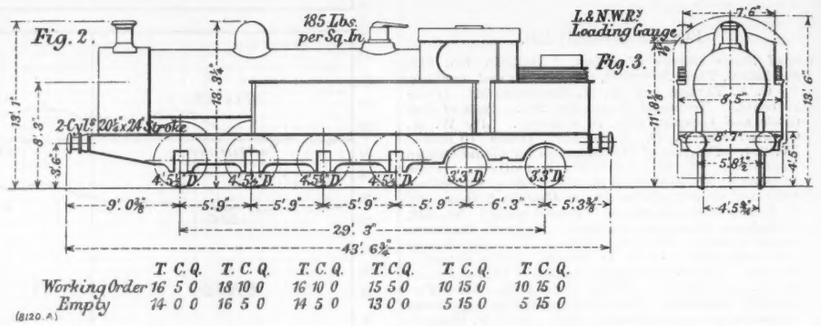
The engines are a development of a class of 0-8-2 type of locomotive which originated at Crewe 12 years ago; the present design was completed in 1921. The eight coupled wheels are 4 ft. 3 in. nominal diameter, and the cylinders 20½ in. in diameter, with a stroke of 24 in. Further particulars we give, for convenience, in tabular form below.

Compared with the earlier class, the new engines have increased tank and bunker capacity, enlarged axle-boxes, slide bars and horn blocks. They are fitted with superheaters. All journals are lubricated mechanically by a pump, and the cylinders by a Detroit displacement lubricator. The engine is fitted with a reversing gear allowing either screw or lever to be used. The valve gear is of the Joy type.

Particulars of 0-8-4 Type Side Tank Locomotive.

Cylinders, diameter	20½ in.
,, stroke	24 in.
Wheels, coupled, diameter ...	4 ft. 5½ in.
,, bogie, diameter	3 ft. 3 in.
Total heating and superheating surface	2,046 sq. ft.
Grate area	23·6 sq. ft.
Working pressure	185 lb. per square inch.
Wheel base, coupled	17 ft. 3 in.
,, ,, total	29 ft. 3 in.
Water capacity	2,030 gallons
Coal capacity	3½ tons.
Weight on coupled wheels in working order	66 tons 10 cwt.
,, total, in working order ...	88 tons.
,, ,, light	69 tons.
Maximum tractive effort at 80 per cent. B.P.	28,711 lb.
Maximum tractive effort at 85 per cent. B.P.	30,506 lb.

The following tests with engines of this type in the South Wales district will give an idea of their capabilities:—On a ruling grade of 1 in 34, with bad weather, a load of 209 tons behind the engine was taken. This load consisted of 31 vehicles, viz., 30 wagons and one 20-ton brake van, and it was started from rest on the grade after the train had been brought up. On another occasion on a ruling gradient of 1 in 40, a load of 392 tons behind the engine, consisting of 59 empty wagons and one 20-ton brake van, was taken with ease and several more wagons could have been added, but for the fact that a greater length of train was inadmissible on the section of the line. In passenger service on a ruling grade of 1 in 34, a train of 14 vehicles, equivalent to 184 tons behind the engine,



was easily handled, the test not being extended to a greater load owing to the length of train of 14 vehicles being as much as the platforms could accommodate.

THE MID-LANCASHIRE ELECTRICITY DISTRICT.

A FURTHER step in the unification of electricity supply has been made by the Electricity Commissioners, who have submitted to the Minister of Transport for confirmation an order constituting the Mid-Lancashire Electricity District and establishing the Mid-Lancashire Advisory Board. The order has to be presented to Parliament and confirmed by resolutions of both Houses, but experience with earlier orders suggests that no hitch or delay is likely at this stage and that the matter will go through practically automatically. The Mid-Lancashire District includes Blackburn, Blackpool, Burnley, Preston, Accrington, Bacup, Chorley, Clitheroe, Colne, Darwen, Haslingden, Lytham, Nelson and Rawtenstall and many urban and rural districts surrounding and connecting these towns. As will be evident from what is said above, the district is to be administered by an Advisory Board in the same way as the South-West Midlands and the South-East Lancashire Districts. So far, we believe, North Wales is the only area in which a joint authority has been established. The Mid-Lancashire Advisory Board is to consist of 33 members appointed by various corporations and urban district councils, and by the Lancashire Electric Power Company, the Lancashire County Council, the Blackburn and Preston Chambers of Commerce, the Cotton Spinners' Association, and the London Midland and Scottish Railway. The whole of the power stations at present in the area, are the property of, and are administered by, municipalities, but the order states that a new generating station which is contemplated in the neighbourhood of Burnley under the technical scheme will be erected either by the Burnley Corporation or the Lancashire Electric Power Company. The technical scheme proposes that 10 existing stations and the new one now being built by the Preston Corporation, shall be retained and operated, and five existing stations shall be closed down as soon as alternative supplies are available. Two of these stations are in Blackpool, two in Preston and one in Blackburn. The standard system of the area is to be three-phase, 50-cycles with a main transmission voltage of 33,000 and secondary transmission voltages of 11,000 and 6,600. New main transmissions are to be laid between Preston and Blackburn, Blackburn and Accrington, Accrington and Burnley, Burnley Nelson and Rawtenstall and Blackpool and Lytham. The technical features of the scheme are to be in the hands of an engineer's committee consisting of the Borough Electrical Engineers of Accrington, Blackburn, Blackpool, Burnley, Preston and Rawtenstall, with an engineer nominated by the Lancashire Electrical Power Company and another nominated by the London, Midland and Scottish Railway.

IMPROVED VOLATILISATION PROCESS FOR ZINC-LEAD SEPARATION.—In connection with experimental work on modifications of chloride volatilisation process, on which the United States Department of the Interior has for some time been engaged at the Intermountain experiment station of the Bureau of Mines, Salt Lake City, it is now announced that in several cases chlorides are left out of the ore entirely and oxides are volatilised. For mixed zinc-lead ores it is possible to so alter them by roasting that the volatile lead oxide can be removed from the ore by further raising the temperature, using a rotary kiln for this latter step of the work. Lead can be almost completely cleaned, and even some of the silver removed from roasted zinc concentrate containing the usual small amounts of lead. This has already been shown by tests on a semi-commercial scale at Harbour City, California. It is believed that not only can this method be used with possible profit by the zinc smelters, but that it is entitled to favourable consideration as a means of concentrating ore. This work is about ready for larger commercial tests, and the Bureau of Mines is now desirous of getting in touch with organisations who would be benefited by the use of this modified process, and who possibly already possess all the necessary equipment required for carrying out the tests.

WIND-DRIVEN ELECTRIC LIGHTING PLANT.

CONSTRUCTED BY THE LAMBERT ENGINEERING COMPANY, HARROW.

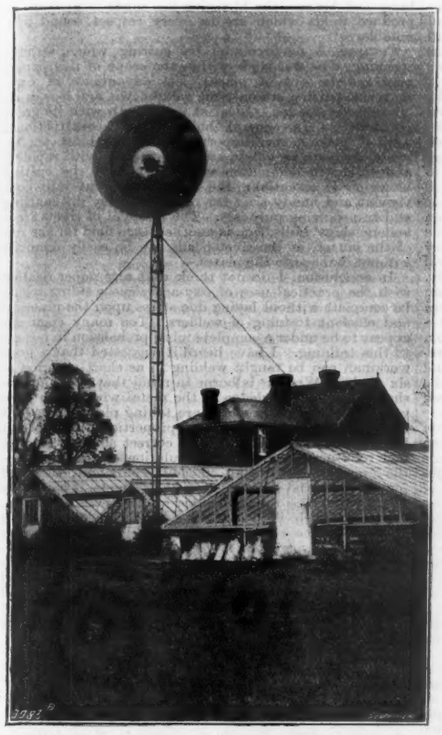


FIG. 1.

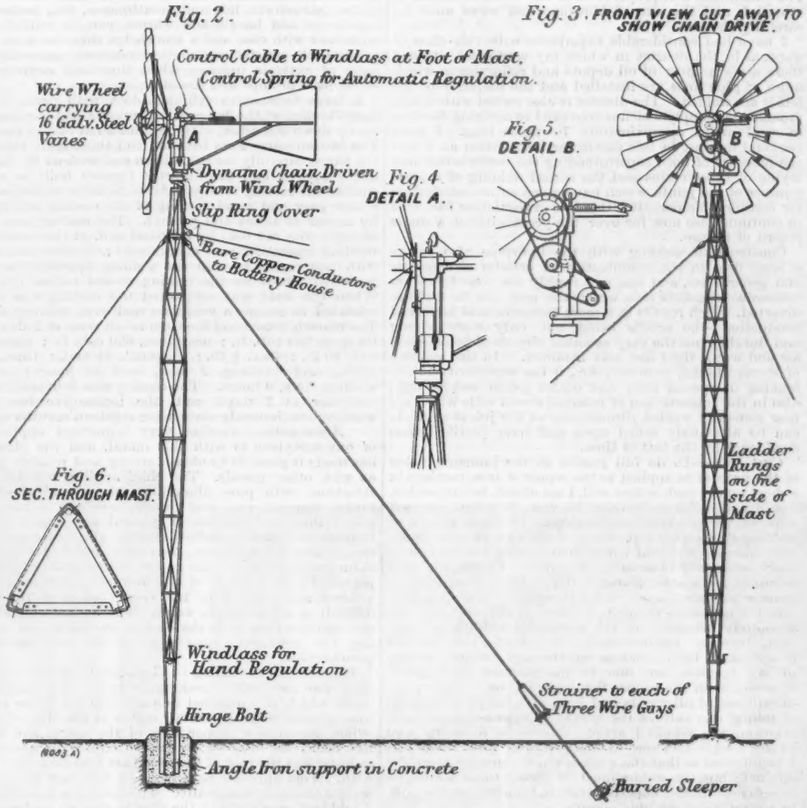


Fig. 2.
Fig. 3. FRONT VIEW CUT AWAY TO SHOW CHAIN DRIVE.
Control Cable to Windlass at Foot of Mast.
Control Spring for Automatic Regulation.
Wire Wheel carrying 16 Galv. Steel Vanes
A
B
Fig. 5. DETAIL B.
Dynamo Chain-Driven from Wind Wheel
Fig. 4 DETAIL A.
Slip Ring Cover
Bare Copper Conductors to Battery House
Ladder Rungs on One side of Mast
Fig. 6. SEC. THROUGH MAST.
Windlass for Hand Regulation
Strainer to each of Three Wire Guys
Hinge Bolt
Angle Iron support in Concrete
Buried Sleeper

PUMPING plants driven by windmills are used to a considerable extent in this country, and may commonly be seen in rural districts. The use of the same motive power for driving electric lighting plant has, however, developed to a much smaller extent, and the possibilities of cheap country-house lighting which lie in this direction do not appear to be generally appreciated. The obvious objection which may be raised to any form of wind-driven electric lighting plant is that the wind in this country is so intermittent that there will always be danger of the plant being shut down over considerable periods. Fears of this kind, however, appear to be ungrounded, and if the plant is run in connection with a suitable battery there is apparently no difficulty about a continuous supply. The Lambert Engineering Company, of Harrow, the makers of the plant which is illustrated in Figs. 1 to 6 above, have had experience with these plants over several years, and have never had a case of the battery failing to give the requisite supply. It is, of course, necessary that a battery of suitable capacity should be installed and that the mill tower should be erected in a reasonably exposed position.

The main features of the Lambert plant will be clear from the figures. It consists of a wind wheel carried at the top of a lattice mast and driving a dynamo through a chain gear. The tail vane is mounted in a common unit with the wheel and dynamo, and the whole is carried on a vertical steel spindle fixed to the head of the mast. The arrangement can rotate around the spindle, so that the vane causes the wind wheel to adjust itself to face the wind. A wire rope leading to a windlass at the foot of the mast allows the wheel to be swung into or moved out of the wind by hand when desired. The wheel and dynamo are so designed that the plant starts charging the battery at a wind velocity of 10 miles to 12 miles an hour, maximum output being attained at about 25 miles to 30 miles an hour. The wheel is mounted so that it can swing on a vertical pivot independently from the vane, and the two are maintained in normal relationship by the spring which is indicated in Fig. 2. In the event, however, of the wind velocity exceeding 30 miles an hour the wheel automatically begins to turn out of the wind so that it cannot attain a dangerous speed. The wind wheel is built on the lines of a bicycle wheel, except in the smallest size of plant in which a tubular construction is employed. The vanes are of galvanised steel. The dynamo is of weather proof design and may be left in operation for long periods without any attention.

The construction of the mast will be clearly followed from Figs. 2, 3 and 6. As will be seen, it is provided at the foot with a hinge, the fixed member of which is formed by two angle-irons carried in a small concrete foundation block. The mast, one side of which is fitted with ladder rungs, is supplied in two sections to facilitate transport. The mast with the head gear may be assembled on the ground and the whole then raised by sheer legs, or other tackle, in half an hour or so, the mast swinging around the lower hinge, which is, of course, first connected up. Three guy ropes with anchors, as shown, are provided to maintain the tower upright. The poles of the dynamo are connected to a pair of brushes bearing on slip rings carried at the top of the mast. From these connection is made to a pair of strain insulators which carry the overhead bare conductors leading to the battery house. The slip rings are provided with a cover to keep rain off. The switchboard which is fitted in connection with the battery carries an ammeter and voltmeter, switches and fuses and an automatic battery cut-in and cut-out.

These plants run with practically no attention, the only service required being some attention to the lubrication once in every two or three months. The running expenses may be looked upon as practically nil, and the saving in running cost over a petrol-driven plant of corresponding size works out at from 15*l.* to 20*l.* a year. This feature of the wind-driven plant should make it attractive even for those cases in which the mast has to be erected in a position which is not so exposed as might be wished. A plant of this kind installed alongside an existing petrol-driven plant would pay for itself in a few years and the petrol plant could be maintained as a standby. Three sizes of these house-lighting sets are built, rated respectively at 50, 30 and 15 lights. The medium-sized plant having a wheel 10 ft. in diameter and a mast 30 ft. high, is illustrated in our figures. The address of the makers, the Lambert Engineering Company, is St. Hilda's Works, Northolt-road, Harrow, Middlesex.

THE PORT OF KONIGSBERG.—Work on the Konigsberg Harbour is being pushed on with considerable energy and is expected to be finished by next summer. There are two new basins, an interior harbour and a free port, which are approaching completion.

PRACTICAL APPLICATIONS OF GAS WELDING.*

By E. A. WHITTAKER.

THIS subject is one of far-reaching possibilities and the time allotted to me will preclude my doing full justice to it. I have been asked to confine my paper to the application and the results of the process from an entirely practical point of view, and I submit the following which, I trust, will be both interesting to those already engaged in our industry, and convincing and helpful to those who are not as yet taking full advantage of the possibilities which the process offers.

Iron and Steel (*Repairs and Construction*).—Dealing with repairs first the subject is too large to consider in detail, but a very good idea can be obtained when one realises that practically the whole of the maintenance repairs for marine, motor and general engineering can be included. Engine machine parts which are continually subject to heavy wear, strain and vibrations which result in fractures and cracks, and worn parts can be readily and permanently made good resulting in a great saving of time and money; especially is this so when the repair is undertaken *in situ* with a portable plant and equipment, which very often is the means of preventing a complete stoppage of work in the factory concerned. Another section of repairs in which the oxy-acetylene blowpipe plays a very important part, is the repairing of boilers and tanks where corroded plates can be built up, cracks, &c., welded and the article reconditioned.

In the section set apart for construction with the oxy-acetylene blowpipe is the erection and maintenance of high-pressure gas, oil and steam pipe lines and the construction of special pipe fittings and connections, viz., tee pieces, reducers, manifolds, headers, &c., far too varied to mention in detail. In the construction of these special pipe connections, the operator must have a thorough knowledge of the effects of expansion and contraction and must take precautions to prevent any distortion from these effects, as it can easily be understood that the flanges and branches must, of course, be in correct alignment for fitting purposes. The best method to counteract these effects is to tack the branch pipe or flange at alternate points and then to weld the joint from these tacks alternately so that the "pull" is evenly distributed throughout the joint.

The expansion effects upon the main pipe in the construction of a main pipe line is very severe, the pipe having a tendency to bend owing, of course, to the weakness caused where the sections are cut away for the fitting of the branch pipes. This effect can be neutralised

* Abstract of a paper read before the Institution of Welding Engineers, on Wednesday, October 10, 1923.

by setting the pipe in the opposite direction, so allowing for this pull, and experience of course is essential for this to be accomplished with accuracy. In the actual welding of these joints no great difficulty is met providing the operator observes the usual rules of application. The cleanliness and preparation of the weld, of course, is essential, and the size of blowpipe and wires must be carefully chosen.

I have had considerable experience with this class of work, as in the district in which my works are situated there are a number of oil depots and refineries in which miles of pipe lines are installed and the majority of the joints are welded. The district is also served with a high pressure gas supply which is conveyed to outlying districts in steel mains approximately 70 miles long. I have personal interest in this particular installation as I had the pleasure of both superintending the construction and laying of those mains and the actual welding of a great number of the joints, which have given entire satisfaction for considerable periods. One line in particular has been in continual use now for over ten years without a single record of failure.

Construction welding with the blowpipe also covers a large field in the manufacture of articles of domestic and general use, and one can readily see that there are numerous channels into which the uses can be and are diverted, which results in a more economic and improved production—the article being not only more strong and durable, but the very essential objects of being made air and water tight are also attained. In the building of storage tanks, receivers, &c., it has superiority in the making of special inlet and outlet joints and fittings; also in the construction of internal steam coils which are now generally welded throughout, as the joints so made can be absolutely relied upon and have justified that confidence by the test of time.

Cast Iron.—To do full justice to the immense value of the process as applied to the repair of iron castings in a short survey such as this, will, I am afraid, be impossible. I will endeavour to convey to you, however, at least some of the practical applications. In the majority of welding shops a big proportion of the repairs come under this classification, and I have had, during the past three years, some very interesting examples. I have purposely refrained from attempting to detail any actual instructions as regards the use of the blowpipe or the operation, but it is necessary to mention a few conditions which are absolutely necessary in the successful welding of cast-iron, because, unfortunately, the application has in many cases been condemned through failures which, in my opinion, are due to inexperience or neglect. Whereas, with the proper manipulation of the blowpipe, careful use of filler rods and flux, and the proper means of taking due care of the effects of expansion and contraction, the repaired article should be in every way as serviceable as a new casting; in fact, these welds can be reinforced so that the work is much stronger than the original; but the welder must, to obtain these results, be experienced in this class of work and undertake the work in a careful and sensible manner.

When the repair of a fractured or cracked casting is contemplated, the welder should, in the first place, very carefully examine the extent of the break or the position, for the purpose of estimating the effects of expansion and contraction. He should then form in his own mind a carefully thought-out plan of action to be taken during the welding operation. By this I mean that a definite method of turning and handling the casting whilst hot, should be decided upon; in addition, minor arrangements should be made with a view of giving every aid to his own comfort, and his materials and protection devices against the intense heat should be so arranged as to relieve him of quite unnecessary and vexatious delays, which are a great danger to the satisfactory welding of a casting owing to the loss of heat.

The actual preparation of the weld should be thoroughly attended to, the bevelling and cleaning of the metal in the vicinity of the weld and, where necessary, supports sprung to prevent a collapse of the metal. It sometimes happens there are certain machined or threaded sections to be preserved, this can be done by using either carbon blocks screwed or fitted into these sections or by filling with carbon paste. The alignment of parts is, of course, a very important item, and should be very carefully attended to. It should then be decided whether the break necessitates total or only partial preheating. If the former, then the method of preheating must be decided, but with the latter, the sections intended to be heated, so as to counteract the local heat of the weld, should be carefully and plainly marked.

Should a total preheating of the casting be necessary, the welder should utilise the best method he has at his disposal for this, as the success of the weld absolutely depends upon a thoroughly even and slow heating and cooling. My own experience with this matter has proved that the method is entirely dependent upon the nature of the casting itself, but generally speaking I think that a furnace built with fire bricks to the shape of the casting, with the necessary room allowed for turning whilst hot, and using charcoal as fuel, is the easiest and most effective. The charcoal will burn steadily, and with attention will bring the casting up to the desired heat for welding; also after the operation has been completed the fire can be replenished, the casting reheated evenly and allowed to cool down very slowly, which is so essential to ensure a satisfactory repair. The actual operation itself depends upon the ability and resourcefulness of the welder. Careful selection of blowpipe and size of rods should, of course, be made, and the proper manipulation of the blowpipe and application of the rod or flux is necessary. The welding must be carried out with the utmost speed and constructed with the greatest care.

Adverting to the object of the paper I will attempt to convey an idea of the great variety and number of articles, which, with the proper application and the necessary care and experience, can be repaired and made good. Marine and general engineering parts, pumps, pulleys, flywheels, worms, drives, brackets, &c., locomotive and tractor cylinders, automobile cylinders, water jackets, sumps, crank-cases, gear and transmission boxes, agricultural machines and parts, furnace doors and plates, gas retorts, lids and mouthpieces, &c., broken or worn cogs and bevels and worms, can be welded and reinforced with ease and a knowledge that the work will prove both satisfactory and economical, especially in cases of extreme urgency when time and anxiety are saved by a prompt and sound repair.

A large locomotive cylinder block with parts of the flange broken off, the flange being broken along one side and partly down the other, may be considered as an example. The broken parts were bevelled and thoroughly cleaned, the flange carefully set in position and secured by clamps and supports, and the firebrick furnace built so as to enclose the casting totally. Arrangements were made to ensure easy and rapid turning of the casting whilst hot by means of slings and pulleys. The casting was then brought to a red heat by charcoal and, at that heat, the welding operation was commenced; it was necessary with this repair to stop the welding operation several times to reheat as the casting cooled rather quickly. When the weld was completed the casting was again reheated to ensure a complete and even cooling down. The materials used and the time taken were as follows:—Oxygen, 700 cub. ft.; acetylene, 600 cub. ft.; cast-iron, rod, 20 lb.; flux, ½ lb.; charcoal, 3½ cwt.; time, preparing and finishing, 2 men, each 34 hours; actual welding time, 9 hours. The casting was delivered to the customer in 3 days, and the locomotive has been working continuously since some eighteen months ago.

Aluminium.—Another very important application of oxy-acetylene is with this metal, and the blowpipe has made it possible to obtain strong and reliable joints as with other metals. The chief applications are construction, with pure aluminium plates and sheets, of tanks, chemical vats and vessels, aero and motor parts and fittings and articles of general and domestic use. Repairs are chiefly confined to the alloy castings, viz., crank-cases, sump cases, gear and axle-boxes, covers, induction pipes and other motor and general engineering parts. In the welding of aluminium a great number of welders are inclined to the view that it is the most difficult of all metals to welds. This is not so, and it is my opinion that it is the easiest providing the welder has the necessary knowledge of its own particular peculiarities.

The successful welding of aluminium depends entirely upon the successful breaking down of the aluminium oxide which is intensified immediately the flame comes into contact with the metal, and it is this film of oxide which prevents a proper flow of the metal and which has been the cause of so many failures in aluminium welding and the root of the idea that it is difficult to deal with. This film can be broken by two methods, either mechanically or chemically. The former is known as the "puddle" method and the film is scraped and puddled at the moment of melting by steel rods specially designed for this.

The latter is by the introduction of a flux which will break up and dissolve the film, and is applied by dipping the filler rod into the flux and so bringing it into contact at the melting-point. Once the welder has become properly acquainted with this operation, and takes the usual necessary precautions as regards the cleanliness of the weld and filler rod and the selection of blowpipes, then the weld should give every satisfaction. When repairs of aluminium castings are undertaken of course, in addition to these precautions the welder must also take the same care whilst preheating as with iron castings and also exercise ingenuity when arranging supports and obtaining the correct alignment.

One of the chief difficulties a welder encounters in the repairing of aluminium crank-cases is that so many are sent for repair with parts either missing or in such small pieces that it is impossible to join them together. I remember one repair in particular of this description. A crank-case off a motor lorry came to me badly fractured and several parts missing. The fracture consisted of a large piece completely broken away from the body of the crank-case, from the bolting-down flange to the cylinder stud holes, also the corner was completely missing. The method of repair in this instance was to build up a part to fit in the corner. This was done with the aid of old scrap castings, parts of which were used and welded to produce a replica of the missing part. The remaining breaks were then bevelled. The whole of the casting was then heated to burn out the oil, a precaution which is very necessary, and if not taken will end in great trouble during the welding, as the welder will find it practically impossible to obtain a join.

When cool, the parts to be welded were scraped thoroughly clean and set with the aid of supports of asbestos fibre and sheet-iron in alignment, the casting was then preheated for welding. This process is sometimes accompanied by difficulty owing to the metal giving no indication as to its temperature by colour, and I have known instances where castings have been totally ruined owing to the casting, through overheating, having collapsed. To prevent this and to be certain that the casting is at a correct temperature for welding, the welder can test by sprinkling over the casting a small quantity of wood dust which will, if the casting is at the proper welding heat, char in about 10 seconds. The casting after the welding operation, was reheated evenly and allowed to cool down very slowly. When cold it was thoroughly washed in hot soda water to remove every trace of the flux, the surplus metal cleaned off and machined surfaces restored.

Copper, Brasses and Bronzes.—Until recently the welding of copper has been a very unsatisfactory proposition owing to the general weakness of the welded portion, but thanks to a great amount of research and experimenting which has resulted in the production of reliable filler rods, it is now possible to obtain sound welds and in the making up of copper tubes from the sheet, coils, heaters, vats, containers, &c., the process is fast making good headway. In repairing castings in brass and bronze, the blowpipe has made it possible to produce welds which are in every respect sound and reliable.

Cutting.—A few remarks on cutting which, strictly speaking, does not come within the scope of this paper, may not be out of place. The advantages of oxy-acetylene cutting are only too well known, and it is quite unnecessary for me to deal at any length with its great possibilities. In general building and constructional work it plays a very important part, as plates, angles, joists, &c., can be cut to any specification with rapidity and ease. In demolition work, of course, the cutting blowpipe is essential; the structure is cut into convenient and handy sizes for rapid and easy dismantling and transporting purposes. The removal of rivets from boilers, ships' hulls, &c., is another large field for the use of the cutter, as the rivet heads can be easily removed without damage to the plates.

In conclusion, I do not think that any paper dealing with the practical uses of oxy-acetylene welding would be complete without laying due stress upon the practical and efficient training of welders. Too many engineers appear to be under a complete misapprehension in respect to this training. I have heard it suggested that a good workman can be taught welding in as short a period as six weeks. When it is borne in mind that every welder should have a knowledge of the metal with which he is working, the changes which are taking place under heat treatment, the restoration of lost properties, the important bearing that oxidisation plays, correct size of blowpipe and rods necessary, the manipulation of the blowpipe, the importance of using efficient equipment, the need for pure gas, and the adjusting of the flame, it can easily be seen that this fallacious idea hardly needs refutation.

Whilst much is being done by technical institutes throughout the country to teach welding to men, my experience is such that before the usefulness of the process can be properly and thoroughly demonstrated it is necessary that a proper apprenticeship should be served under capable tuition, and even then, when this standard is reached, the welder will find that he must keep himself posted with current literature to maintain that efficiency owing to continual fresh discoveries.

THE CAUSES OF RAPID CORROSION OF CONDENSER TUBES.*

By Guy D. Bengough, M.A., D.Sc., R. May, A.R.S.M. and Ruth Pirret, B.Sc.

The corrosion of condenser tubes must be considered as primarily a chemical problem, and therefore, the concern of the chemist and metallurgist, rather than that of the engineer. Accordingly, the matter has been studied in detail for some years under the direction of the Corrosion Research Committee of the Institute of Metals, the chairman of which is Professor H. C. H. Carpenter, F.R.S.

The general appearance of an affected tube is that of a "nibbled" or water-worn material (see Fig. 1), but under the microscope the actual metal surface in the hollows is seen to be very smooth, instead of roughened as with ordinary corrosion. The attack is frequently distributed over a considerable length of tube instead of being confined to a small isolated area, as it usually is with other types of action. Two feet or 3 ft. of the tube may be affected, and the attack may be distributed all round the tube, or it may occur principally at the top, bottom or sides, quite indifferently (see Fig. 2). Irregularly shaped areas of the tube stand up like escarpments from the more severely attacked material (see Fig. 3). When these areas are small they are sometimes associated with crescent-shaped, deeply attacked troughs which are always on their up-stream side. The deeply-attacked areas are covered only by very thin layers of corrosion product; sometimes so little that it is difficult to detect it. No metallic copper is to be seen. A small amount of cuprous oxide may be present, and some ferric hydrate from the water-ends, but very little green or blue basic salt.

Only the examination of actual specimens will give a true idea of the appearance of the tubes.

The corrosive action is most commonly found in the first pass, towards the ends of the tubes at which the water enters, and generally within the first 3 ft. or 4 ft. In very severe cases even the first inch or two of the tube may show it, but often 4 in. or 5 in. are free from it; then the action begins and may extend for 3 ft. or 4 ft. along the tube. The whole of the rest of the tube may be unaffected. Sometimes, however, it breaks out again near the water-outlet end of long tubes of 14 ft. or more, and may affect a length of a foot or two and then disappear a few inches from the end.

Protector blocks of iron, steel, zinc or aluminium have little or no effect in checking the action, and even the presence of a current of 3 amperes to 5 amperes per 1,000 sq. ft., tending to make the tube cathodic, is unable to affect any useful amount of protection (see Fig. 4). Experiments using a current density as high as 10 amperes, per 1,000 sq. ft. (which is about twice the amount usually adopted for electrolytic protection), have clearly shown the rapid failure of tubes even in these conditions. Ferrules, which are usually made of 60 : 40 alloy, are sometimes affected as well as tubes (see Fig. 5

* Abstract of a paper read at the meeting of the North-East Coast Institution of Engineers and Shipbuilders Newcastle, on October 19, 1923.

reproduced from *The Engineer*, July 6, 1923). In spite of the high percentage of zinc in the ferrule alloy it frequently happens that no redeposited copper is to be seen in the corrosion product.

As regards this type of attack, the critical period for a tube is the first few weeks of its life; if it survives this period without the attack starting it is quite likely never to suffer from it.

There appear to be two possible lines of work along which a palliation for this serious corrosion menace may be sought; first, the search for new alloys, or methods of treating alloys, different from those at present in use for tubes, and second, a system of recording the exact positions of all tube failures in condensers with a view to the avoidance of placing new or untreated tubes in those positions.

Unfortunately the problem is urgent—a statement that may be illustrated by the present authors' experience of ordinary 70 : 30 brass tubes failing repeatedly in certain power-station plants in periods varying from 17 days to six weeks, and in marine practice in three or four months. In other condensers, apparently quite similar, and working in the same station or sister ships, the average life of a tube may be measured in years; fortunately the latter is the usual case, but the uncertainty is a serious matter. Such a state of affairs calls for careful consideration from every point of view, and it is believed that engineers may be able to assist in reducing the number of very rapid cases of corrosion when once certain facts concerning corrosion phenomena have been placed before them.

The engineer in charge of a plant is usually able to ascertain the average speed of the water throughout a given condenser, but he is not in a position to ascertain the actual speed through any given tube. Neither can he ascertain how the speed varies near the tube wall, nor how far turbulent motion extends in any one tube. A knowledge of the average speed gives little information on these points. Yet all these data have a very important bearing on the rate of corrosion in a tube. An engineer is frequently unable to say whether or not entangled air is passing through his condensers in the water stream, and, if it is, he is never able to ascertain through which tubes it is passing in largest quantity. This is a very important factor in corrosion.

By experimenting with glass tubes of similar dimensions to condenser tubes and fixed to tube plates with ordinary ferrules and packing, it has been found that noticeable variations from the average speed occur in different tubes. Moreover, the water entering certain tubes may assume a condition of spin, and turbulent motion often takes place near the inlet ends of tubes. In the inlet water-box turbulence usually occurs and this may occasion an irregular distribution of entangled air which has passed out of, or has never been in, solution in the water; frequently local vortices are formed in water ends containing air at their centres, and this air is very unlikely to be distributed uniformly through the tubes. In a single tube the water in the centre of the tube usually travels faster than the water near the wall, and in certain conditions small eddies may form locally in such a way that the water in contact with the tube wall may be flowing in the opposite direction from that in the centre of the same tube. In some positions actual impingement of entangled air on the tube wall may occur, and this is a very important factor in corrosion. It is improbable that any two tubes in a single pass of a single condenser are under precisely similar conditions from a corrosion point of view.

If the corroded tubes can be seen to contain coppery areas it is thought that the tubes must have contained free copper when new; if no copper is visible as is the case with the type of corrosion here discussed, it is contended that they must have contained free zinc, which since it cannot be seen, must have been corroded away and disappeared. The general justification for such views is that there is no other available explanation for the rapid failure of the tubes, and that sets of tubes made by the same or other makers have stood up well in times past.

The authors' experience, which covers many hundreds of tubes, is quite definite on one point; they have never observed a single case of a new tube which contained either free copper or free zinc in the body of the tube wall. It often happens that red "pickle stains" are found on the surface of the tubes. These consist largely of metallic copper but are purely superficial and never exceed one or two hundredths of a millimetre in thickness and are usually much thinner. They are formed by chemical reactions in the pickling vat and are not due to bad mixing in the crucible. From the condenser corrosion point of view they are harmless.

PART I.—THE MATERIAL OF CONDENSER TUBES.

Manufacture.—The melting-point of pure copper under charcoal is 1,083 deg. C., that of zinc 419 deg. C. The ordinary mixture contains only 30 per cent. of zinc. From these figures it is clear that if the copper is above its melting-point there is no chance for free zinc to exist in a tube; when the zinc reaches the crucible it will rapidly melt and diffuse into the copper to form a molten solution, the melting-point of which is about 930 deg. C. In order to get the alloy to flow properly in the iron ("chill") mould, however, it is common practice to pour the alloy at temperatures over 1,100 deg. C. Pouring temperatures appreciably less than 1,000 deg. C. cannot be used in practice as the resulting "shell" would be porous and spongy, and either could not be drawn at all or would yield a tube full of flaws, laminations, and oxide inclusions, which would not pass the most casual inspection. In practice it is as low as 0·02 per cent. Although it is desirable to keep the iron as low as possible in a tube, the effect of even 0·3 per cent. is not sufficient by itself to account for the rapid failure of a tube in a few weeks or even months; its influence determines the type of corrosion more than the rate. Nickel, manganese, bismuth, antimony, and arsenic are usually only present in amounts denoted by figures in the second or third places of decimals and, in such amounts, the first four have not been observed to affect the rate of corrosion in any important degree. The only metal in the above list that need be considered in any detail when present in mere traces is arsenic. Its effects may be decidedly harmful in certain conditions and beneficial in others. The presence of arsenic, however, cannot be the main cause of the rapid type of corrosion, since tubes free from arsenic have been found to fail in very short periods. It is, however, a contributory factor in certain circumstances.

The only conclusion that can be drawn from the large amount of data at present available is that there is no simple relation between the composition of ordinary tubes and their lives in condenser practice, within the limits of composition that commonly occur in commerce. If, however, the total "impurity" in a tube approaches 1 per cent., as occasionally happens in practice, the behaviour of the tube may be seriously affected.

Quite apart from chemical composition, tubes may differ among themselves in physical properties. All brass condenser tubes come on the market in the hard-drawn condition, but considerable variations in hardness between different batches may occur. It is reasonable to suggest, therefore, that there may be some relation between hardness and corrodibility. Here again, however, all the evidence goes to show that there is no such direct correlation. It is true that it has been found that the flowed surface layer of hard-drawn tubes is more resistant to corrosion than the underlying metal, but experiments on specially hard-drawn tubes which may be presumed to possess a specially thick flowed layer, have not, so far, shown a decided advantage for such tubes over ordinary ones; probably there are positions of thinness or discontinuity in the resistant surface layer, which is largely removed by exfoliation. There appears to be a slight gain in having a finely crystalline structure in the tubes, but even the finest structured tubes will rapidly fail in bad conditions.

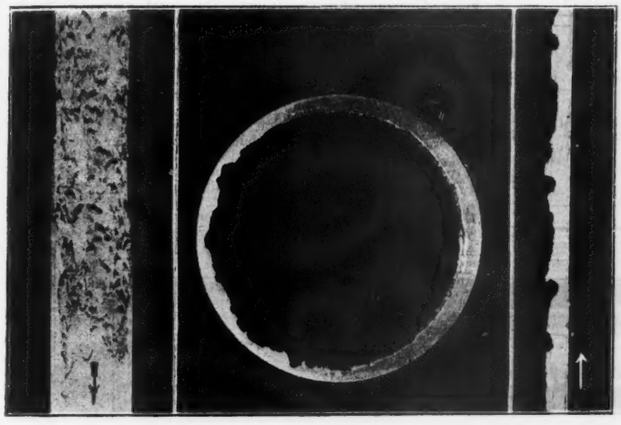


FIG. 1.

FIG. 2.

FIG. 3.

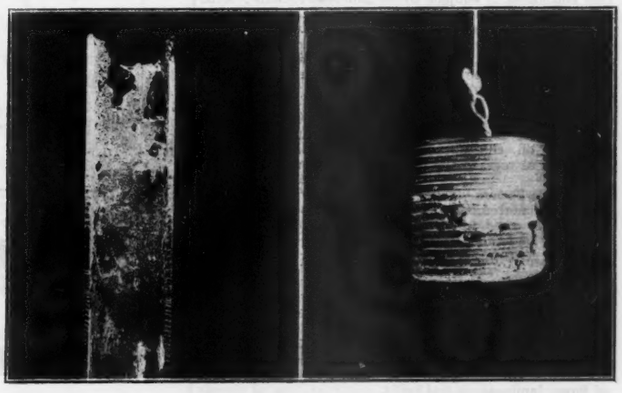


FIG. 4.

FIG. 5.

FIGS. 1, 2 AND 3. GENERAL APPEARANCE OF AN AFFECTED TUBE. IN FIGS. 1 AND 3 THE DIRECTION OF FLOW IS SHOWN BY ARROWS. FIG. 4. ACTUAL END OF TUBE COMPLETELY CORRODED AWAY IN SPITE OF "ELECTROLYTIC PROTECTION" BY AN EXTERNAL CURRENT. FIG. 5. AFFECTED FERRULE OF 60 : 40 ALLOY.

A line of investigation pursued in the endeavour to estimate the influence of the material of tubes on the rate of corrosion consisted in observing the behaviour of tubes of known composition and properties when placed in different condensers, and in different positions in the same condenser. For these tests, tubes obtained from several different makers were used, and the tests were mainly carried out in condensers in which rapid failures of tubes were frequent in order to shorten the times of the tests. Even so they take a considerable time.

The best procedure known to the authors for carrying out such tests will now be described: A plan of the tube plate of a two-pass condenser such as that shown in Fig. 6 is first made and the position of every tube marked on it. The whole condenser is then retubed with tubes made by, say, three different makers, A, B, C. At least 200 tubes by each maker should be placed in each pass so that the number of makers whose tubes can be compared is limited by the number of tubes in each pass. The condenser is then run in ordinary conditions of practice.

As soon as a tube fails it is withdrawn and its position and the date noted on the plan. It is then replaced by another tube by the same maker. It often happens that this tube will also fail quickly; and sometimes several tubes in the same position will fail one after another, while tubes in other parts of the same condenser stand up well. At the end of six months, in a bad case, the distribution of tube failures in the condenser may be as shown in Fig. 6, which is taken from actual practice.

At first sight it would appear that A's tubes are at

Copyright

fault, and it is clearly advisable to withdraw his tubes and replace them by say, new tubes made by B. When this has been done future events will usually take one of two courses; either no more failures will occur, in which case A's tubes were probably bad (provided that no change in average water-speed, vacuum, or air and water supply has occurred), or B's tubes will fail in the same, or nearly the same, position as A's. In the authors' experience the latter has nearly always been found to be the case.

In order to decide definitely whether A's tubes were faulty it is desirable to withdraw B's tubes from the middle section of the condenser and replace them by new tubes of A. In such cases it is usually found that these tubes endure just as well as B's did in that position. The only conclusion to be drawn is that the main factor in determining the corrosion is to be found in the conditions in certain parts of the condenser. If further confirmation is required a batch of C's tubes may be placed in the left-hand section of the condenser. It will not do, however to transfer C's tubes from the right-hand section; if this were done it is quite possible that C's tubes might endure, but the comparison would not be fair because it would be between new tubes of A and scale-coated tubes of C, a comparison unfair to A, as will be shown later.

It is comparatively seldom that it is possible to carry out the complete programme indicated above, but portions of it have been performed on a number of occasions. With one exception, in every case in which the type of corrosion in the condenser has been that described at the beginning of this paper the result has been to exonerate the tubes from blame for failure.

The position as regards the effects of the chemical and microstructural character of condenser tubes may be briefly summed up as follows:—

(1) Within the limits of composition usually obtaining in 70 : 30 and Admiralty brass tubes of commerce, there is no direct relation between such composition and the extremely rapid type of corrosion which is now under consideration; if, however, arsenic occurs in the tube this statement is subject to certain reservations; with unusually large amounts of "impurity," such as 1 per cent., the tubes may behave very badly.

(2) The variations in crystalline structure and physical hardness, which commonly occur between different batches of such tubes are not directly related to the rapid type of corrosion now under consideration; they are no more than minor factors.

(3) The proportion of certain minor constituents of brass tubes, particularly arsenic and iron exert an influence on the nature of the corrosion products, especially as regards the presence or absence of metallic copper.

Defective Tubes.—It does not necessarily follow from the above statements that all tubes which reach the market are good. The following is an analysis of an unusually bad tube:—

Copper	70·21
Zinc	28·75
Iron	0·49
Lead	0·12
Tin	0·35
Arsenic	0·03

The most frequent defect to be found in the ordinary 70 : 30 and Admiralty tubes of commerce is the presence of flaws, laminations and spills.

There are usually discontinuities or cavities in the tube wall frequently arranged with their longer axes along the tube. They may extend only a fraction of an inch, or in rare cases as much as 2 ft. or 3 ft., along the tube (see Fig. 7). Such cavities are often partially covered with a lip which can be easily raised from the surface of the tube. These cavities may contain oxides of copper and zinc, and sometimes a little carbonaceous matter. They are usually quite superficial, but in some cases may penetrate one-third through the wall of the tube. Such defects mainly arise in the casting house, and are due, in some cases, to insufficient skimming, low casting temperatures, or careless pouring.

The defects may seriously impair the mechanical properties of tubes, and for that reason users are clearly entitled to reject them as unsatisfactory. Such flaws have in the past been cited as one of the initiating causes of local corrosion. The authors have made a very large number of observations on this matter and have formed the definite conclusion that they are not originating causes of the rapid corrosive action now being considered. Tubes known to be quite free from such flaws have suffered the rapid type of action, and tubes containing them have not corroded more rapidly in the early stages than normal tubes. In the later stages of corrosion, however, flawed tubes are liable to suffer considerable losses of metal by "exfoliation," a process of mechanical loosening which is sometimes associated with corrosion.

The position as regards flaws and laminations may be briefly summarised as follows: Tubes containing them should be rejected by users on mechanical grounds, and owing to the fact that when corrosive action has once started the tube wall is liable to lose an unduly large amount of metal by exfoliation. Flaws and laminations, however, do not initiate rapid corrosion in conditions in which it could not occur in their absence, and cannot, therefore, be regarded as the cause of the action under discussion.

Part II.—Conditions in which Tubes are Placed.

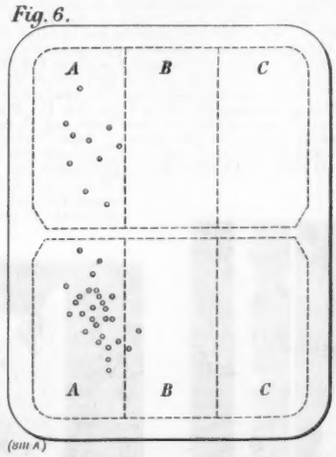
Types of Industrial Waters.—Waters used for condenser circulation may be very roughly divided into two chief classes (which have numerous sub-divisions), namely, high chloride waters and low chloride waters.

By far the greatest number of corrosion troubles arise from high chloride waters. Such waters may contain anything from about 500 to 2,500 or more parts of chloride per 100,000. Waters of intermediate types, especially when passed over cooling towers whereby certain constituents are caused to accumulate, sometimes give rise to trouble, but in the present paper only the high-chloride waters, such as estuarine and sea waters, will be considered. In the authors' experiments natural sea-water has been chiefly used.

The Nature of Corrosive Action.—Before considering specific cases of condenser tube corrosion trouble it is necessary to give a brief outline of the nature of corrosive action, with special reference to copper and brass.

When copper or brass is placed in sea water, a scale is formed all over the surface. Such a scale may contain the following constituents in the case of copper: (1) Crystals of redeposited copper; (2) cuprous oxide—as amorphous or sub-crystalline oxide (red or yellow-red) or as crystalline cuprite (red); (3) cuprous chloride; (4) cupric hydroxide (blue); (5) basic copper carbonate (blue); (6) cupric oxychloride (green); (7) brown or black hydrated oxides or hydroxides (especially at temperatures approaching 50 deg. C. and upwards). It may also contain calcium sulphate and carbonate and small quantities of magnesium and silicon com-

Fig. 6.



(SIII A)

pounds, but in the case of a badly corroded tube these are of comparatively little importance. The surface layer of scales may contain in addition ferric hydroxide and other extraneous substances.

A scale is thus seen to be a mixture of a number of bodies which differ considerably from one another in both chemical and physical characteristics, and it is by no means homogeneous. The composition differs at different localities and undergoes changes with time.

Crystals of redeposited copper are comparatively rare constituents of a copper scale; they are common with 70 : 30 brass and some other alloys, but not in the conditions now to be considered; they are formed in the case of copper as the result of "metalion concentration cell" action, and will not be discussed further. Cuprous oxide in noticeable amounts is sometimes almost absent from the tubes placed in strongly oxidising conditions and heavily corroded. In such conditions it is also sometimes difficult to detect cuprous chloride; this substance is soluble to a limited extent in sea water and in alkaline chlorides generally, and is oxidised fairly rapidly to cupric chloride and cupric oxychloride or cuprous oxide. The carbonate may be present only in small amounts in a scale.

A sea-water scale on copper, therefore, always contains cupric hydroxide, basic carbonate, and cupric oxychloride, and usually cuprous oxide. The proportion of these substances may vary considerably according to the conditions in which corrosion took place.

The occurring mixtures of hydroxides with oxides and basic salts, &c., may in certain conditions adhere in part to the metal from which they were formed, and so give rise to a more or less protective scale.

The scale on a brass tube contains not only constituents formed from copper, but also some formed from the zinc, particularly zinc hydroxide, basic zinc carbonate and zinc oxychloride; some of the zinc usually passes away in solution.

The rate of corrosion of copper or brass in a liquid is largely determined by the rates at which metalions are removed from the metal surface and oxygen reaches it. If the corrosion products form a scale which is highly pervious rapid corrosion will take place; if the scale is only slightly pervious, the metal will be largely protected. Thus the chemical stability of copper and many of its alloys in natural waters, is mainly dependent on the nature of the scale formed.

It is clear that a scale must largely consist of substances insoluble or nearly insoluble in the prevailing conditions; but insolubility is by no means the sole factor which decides the protective value of a scale, and its constituents; thus certain insoluble sulphides have little protective value in sea water.

Other physical factors which determine the protective powers of a scale of given composition are: (1) Power of adhesion to metal when wet and when dry; (2) resistance to erosion, or disintegration by mechanical means; (3) thickness; (4) state of aggregation, *e.g.*, whether crystalline, gelatinous, porous, &c.; (5) permeability to water and oxygen (in solution).

An indirect factor is the temperature, which affects certain of the above direct factors and also the composition of certain scales.

The term "resistance to erosion" is used to signify the resistance of the scale to mechanical action tending to tear it apart; the term "power of adhesion" its resistance to action tending to tear it away from the metal.

In addition to the above physical characteristics a scale of high protective value should be chemically stable in the prevailing conditions. The constituents of scales differ considerably in this property. Thus the crystalline oxychlorides of copper and zinc appear to possess considerable chemical as well as physical stability, but cuprous chloride and zinc hydroxide are liable to undergo slow but important chemical reactions which are accompanied by physical changes, such as crystallisation, which impair protective value. Such changes do not usually take place uniformly throughout the whole scale, but appear first at certain definite positions;* the result is that an increased rate of attack, producing local pitting in extreme cases, may appear at corresponding positions. The local chemical breakdown of a scale is thus one important cause of local action, and in the older condenser practice characterised by a low vacuum, a low water speed, and a minimum of foaming and turbulence, the most important one.

Some scales appear to possess the property of partial permeability; *i.e.*, they allow access of oxygen and other substances in solution to pass slowly through the scale and reach the metal, but markedly hinder the diffusion and convection of corrosion products outwards through the scale; the result is local accumulation of corrosion products. In some cases this may lead to swelling or "blistering," porosity, and finally to the fracture of the scale with consequent renewed exposure of the metal to oxidation. In other cases it may lead to the re-

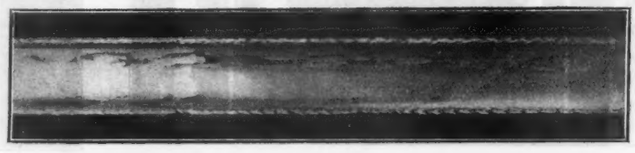


Fig. 7. Tube with Typical Cavities.

deposition of substances from solution (*e.g.*, metallic copper), and thus cause so-called dezincing.

In the case of copper and brass the power of adhesion of a scale is considerable in stagnant sea water, but is inadequate in flowing water in certain conditions. It may be noted, however, that in some cases, *e.g.*, the manganese-copper alloys in certain conditions, the power of adhesion is much smaller when dry than when wet. If a scale becomes detached the exposed metal is again oxidised, probably with great rapidity; consequently repeated removal of a scale results in active corrosion. For this reason alternate wetting and drying is very harmful to some metals and alloys, because it alters, cracks and removes their scales.

Experiments on Scale Erosion.—It will be realised that the properties of a scale as regards adhesion to metal, resistance to erosion (*i.e.*, mechanical removal) and other physical factors are a matter of great practical importance. The subject has a direct bearing on the rapid failure of condenser tubes in practice, and, therefore requires discussion in this paper.

The principle adopted in the investigation of this matter is the use of a jet of aerated water to erode the scale. The advantages of this type of test are that it is not liable to cause true erosion of the underlying metal, and that it is actually one of the most active causes of corrosion in conditions of practice. The test has been standardised and rendered quantitative as far as possible by the adoption of the following arrangements:—

A stream of water travelling at the average rate of 10 ft. per second and carrying, in suspension a definite volume of entangled air, is caused to impinge at right angles on to the surface of the metal the scale of which is to be tested. The metal surface is fixed at a distance of 2 mm. from a glass jet 2 mm. in diameter, through which the stream of water and air is led. The standard time for a test is one month (28 days). A diagram of the apparatus is shown in Fig. 8 (left-hand portion). The test can be carried out at atmospheric temperature or at a higher temperature if desired. A kind of water-hammer

* In this connection it should be borne in mind that scales are not uniform mixtures: on the contrary the different constituents tend to be distributed irregularly under the action of a water stream, gravity, &c.

effect is produced by the difference in specific gravity between air and water, and if the air is present in bubbles of a certain size its action is considerable.

It may be thought that water-hammer produced in this way might erode the metal as well as the scale, but that this is not the case has been shown by comparing the effect on rolled copper and rolled gold, which can be obtained in forms which have nearly similar mechanical properties. At the end of one month the effect of this test on gold is too slight for detection by microscopic observation or by weighing, while on copper the average loss of thickness opposite the jet is 0·20 mm., an amount that is not only readily detected by the unaided eye, but easily measurable by micrometer. The difference between the two results is due to the fact that the gold is not dependent on a layer of hydroxide and oxy-chloride, which is partially or wholly removable by the air-water jet, for protection from oxidation. A further argument against the view that actual metal is eroded is to be found by comparing results obtained with distilled water and sea water. If the mechanical erosion of metal were the principal action, the action of distilled water ought to be almost, or quite, as severe as sea water; in actual fact the rate of attack by distilled water, though quite measurable, is less than one-tenth that of sea water.

Tables of tests in the paper (not reproduced), on copper and brass give the results obtained with commercially pure copper, and arsenical copper tubes, the angle of the jet being varied; they also show tests in sea water with various amounts of entangled air, &c. The attack of the jet test is not very great provided that not more than a certain maximum amount of air is present, but after that amount is passed it becomes very important. The total volume of air, however, is not the only factor of importance; the size of the bubbles also appears to affect the results. Within limits which cannot yet be

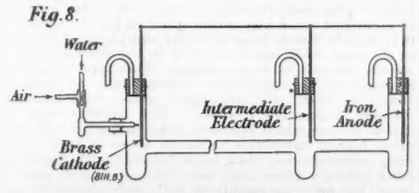


FIG. 10. SPIRAL FLOW OF AIR AND WATER THROUGH EXPERIMENTAL TUBE.

definitely stated small bubbles appear to be more harmful than larger ones, and this remark raises the important question of foaming. The sample of sea water used in the tests did not "foam" at all readily, *i.e.*, the air was present in comparatively large separate bubbles, except when a very large volume of air was used. Foaming then became pronounced, and very active corrosion occurred, the tube being nearly penetrated in a month.

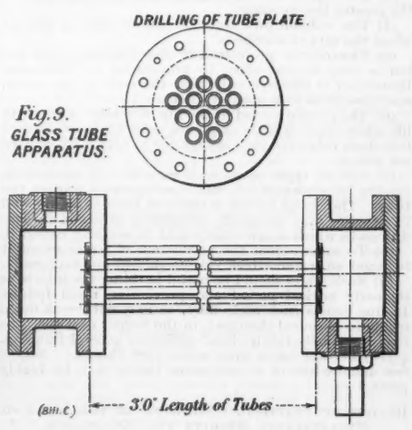
If the temperature of the tests be raised to 40 deg. C., the rate of corrosion of brass is lessened; thus the effect of temperature is different from that recorded for copper. The reason for this is clear from a study of the effect of temperature in stagnant water. In the case of 70 : 30 brass the corrosion attack starts more rapidly, but falls off more rapidly as the temperature rises to 50 deg. C., owing to the formation of a more protective type of scale. These facts should be correlated with the effect of higher vacuum in condenser practice, which causes a lower temperature at the tube walls, and consequently more corrosion.

Types of Corrosion found in the Jet Test.—The results for 70 : 30 brass have been obtained in most cases on tubes which show "complete corrosion" under the jet test. This term is commonly restricted to cases in which metallic copper is absent, or nearly absent, from the corrosion products. If the metallic copper is present in amounts noticeable to the unaided eye the action is commonly known as "selective corrosion" or "dezincification." These two last terms came into use during the period when it was supposed that the zinc in a brass tube was "selectively" attacked and removed in preference to the copper, and that the latter was left behind in the metallic state. This is now known to be incorrect; the brass is initially attacked practically as a whole, but in certain conditions the copper is redeposited from solution by secondary reactions and may form what appear to the unaided eye to be pseudomorphs after the original brass. Microscopic observation, however, shows that the copper is in the form of minute crystals of quite different form from the original brass. Such action sometimes takes place locally only, the copper appearing in the form of plugs in the tube; or it may occur over wide areas of the tube, which is gradually replaced by a weak and porous copper shell. The mechanism of the action is somewhat complicated, and its occurrence is dependent upon the formation of certain types of semi-permeable scale on the tube. Thus the presence of plugs or areas of copper in a tube does not necessarily point to bad mixing in the course of manufacture, but results from purely corrosive action; they may be formed in tubes which are known to have contained no free copper before corrosion began, and to have been of thoroughly satisfactory quality, provided that the tube contains no arsenic.

Two of the most important factors which control the presence of redeposited metallic copper are the temperature and the presence of arsenic. Of these the presence of arsenic is the more powerful. A mere trace of this substance, *e.g.*, 0·01 per cent., is usually sufficient to suppress entirely the appearance of copper, *i.e.*, to prevent redeposition from solution; instead, it becomes oxidised to cupric hydroxide and oxychloride. This effect is remarkable, and in the whole volume of corrosion literature there is, as far as the authors are aware, no case recorded in which the presence of such a trace of metal can so greatly affect the course of corrosive action. Even the amounts of the order of 0·005 per cent. have an appreciable effect, and many tubes in commerce contain amounts of this order.

An increase of temperature from atmospheric to 50 deg. C., and probably higher, has a less powerful effect but opposite to that of arsenic, *i.e.*, it tends to assist deposition of metallic copper. Increased amounts of iron, manganese and zinc and the dilution of the sea water all increase this tendency, but become effective chiefly when arsenic is absent, or present only in minute traces.

When copper is deposited in important amounts the rest of the scale on the tube is often white or only slightly stained blue. Such a scale consists mainly of zinc



hydroxide, basic carbonate and oxychloride. The latter is the constituent which is chiefly responsible for conferring on the scale the property of partial permeability which appears to be necessary for the deposition of copper. The presence of large amounts of zinc oxychloride appears to strengthen and harden the scale so that, when once formed, it is not easily knocked off in the jet test; it remains on the tube, but owing to its partial permeability corrosive action can go on beneath it—of course more rapidly near the jet than elsewhere. Consequently the copper deposits gradually spread. The white scale containing much zinc oxychloride is not the only scale which causes copper deposition. Any type of scale which allows slow penetration of sea water to the brass but hinders the outward diffusion of soluble corrosion products such as copper chloride, may cause the deposition of copper. Thus certain foreign substances settling on a tube may set up the action.

Both tubes which will show copper deposition and tubes which will not are readily obtainable in commerce, but no general statement can yet be made as to which is the best for use. Facts may be quoted to support the view that it is best to use a non-dezincing tube. In other experiments, however, the position would appear to be reversed. A tube taken from a Yarmouth trawler and which had been in service eighteen years, whose thickness had been diminished by less than 5 per cent., showed no copper deposits. It would appear that in some sets of conditions one type of tube is best and in others the other; probably with low vacuum and low water speed, *i.e.*, high condenser temperature, an arsenic-bearing tube is best, but where air-water erosion is liable to occur, *i.e.*, with high water-speed and vacuum, an arsenic-free tube.

Measurements were taken in which the total volume of entangled air present in the water stream was varied. It has already been pointed out that the amount of corrosion is not determined solely by the total volume of air. If a given volume of air is passed through a tube in the form of a few large bubbles it is much less harmful than the same volume would have been in the form of a large number of small bubbles. The intimate mixture of air and water known as "foam" appears to be the most harmful form in which air can be present. Most samples of sea water foam readily when in active motion in the presence of air; distilled water, rain water, London tap water and some other natural waters do not. Different batches of sea water frequently differ considerably in their foaming properties even when taken from identical positions.

In addition to speeding up certain chemical reactions by penetrating the scale, air bubbles can apparently assist corrosion by two purely physical methods. Thus, the air can exert a certain amount of "water-hammer" action on the scale owing to the difference in specific gravity between air and water. Such action naturally tends to loosen the scale whenever it takes place. The second mode of action is rather more complicated; it arises from the interfacial tensions of the bodies concerned. When an intimate mixture of air and water is present at a corroding surface of copper or brass the products of the action (which are largely basic salts) tend to arrange themselves at the air-water interface rather than at the metal-water interface. It is, of course, on the latter position that they have the greatest protective power, whereas when arranged round the surfaces of bubbles, they have none; consequently greater corrosion normally takes place at areas at which air, water and metal all meet.

Observations on Aerated Water Streams.—The principle of the apparatus used is shown in Fig. 9. A stream of water is pumped by means of a centrifugal pump through a length of lead pipe into an iron water-box attached to a brass tube plate in which are held, by ferrules, glass tubes of the same internal diameter as condenser tubes. The water stream is obliged to turn through a sharp angle, usually about a right angle, at the point of entry into the tube, as usually happens in condenser practice; the water-stream passes out of the tubes at the other ends and is collected in a large stoneware vessel, whence it passes again to the pump. If sea water was used fine air bubbles could always be detected in the stream. The origin of this air is probably a slight churning effect in the pumps. Owing to the difficulties of observation with very fine bubbles, most of the experiments were carried out with the needle valve slightly open, so as to admit extra air.

The behaviour of the water-stream carrying its entangled air was found to be of great interest from the corrosion point of view. In many conditions of speed and entrance angle the water and air assume a condition of spin which causes spiral flow through the tube. This is illustrated in Fig. 10; the spiral flow gradually dies away along the tube.

In some cases, especially at low water speeds, the air travels slowly along the top surface of the tube. At higher speeds part of the air, and especially the large bubbles, may be concentrated into a flat spiral track in the centre of the tube where, of course, it would be comparatively harmless from the corrosion point of view. At still higher speeds, such as 10 ft. per second, this concentration is not so effective, and a bombardment of the wall of the tube with a spray of air bubbles may take place. The greatest degree of concentration in a central spiral appears to take place when the water connection is off-set from the centre of the tube, but here again the effect decreases with increased speed.

At very low water-speeds part of the air tends to rise in the stream and stick to the upper surface of the tube.* Round these bubbles eddies occur and occasionally water can be observed travelling in a direction opposite to the main stream. This kind of phenomenon was best studied by introducing fine solid particles in suspension in the water stream; in a condenser tube there would always be such particles consisting of insoluble corrosion products, ferric hydrate and foreign matter.

Some measurements have been made on the speed of the air bubbles at different points of the tube. The speeds may differ considerably. Bubbles in the centre may travel at a speed approximately twice the average water speed; those near the tube wall may be almost stationary. At some places especially near the water-inlet end, turbulent motion may occur accompanied by such an air-bombardment of the tube wall that the resulting vibration can be felt by the hand. Further along the tube the individual bubbles tend to collect into a central spiral stream, the spiral gradually becoming flatter along the tube. All the bubbles are never collected into this spiral; the smaller bubbles tend to travel in independent spirals which sometimes cause local bombardment of the tube wall. At a distance of 2 ft. or 3 ft. from the inlet end the spirals tend to flatten sufficiently to give paths approximately parallel to the tube walls.

When these experiments are considered in conjunction with the air-impingement tests it will become clear that the life of ordinary arsenical copper or 70 : 30 brass tubes in a condenser using sea water which contains entangled air may be very brief, sometimes as short as three or four months. Moreover, the distribution of corrosion in a condenser will follow the distribution of entangled air, and the distribution of this air has already been shown to be a complex and rather uncontrollable factor.

One additional factor which may reduce the life of a tube to a mere matter of days is the presence of sulphuretted hydrogen. This gas may be present in noticeable quantities in the estuaries of rivers which flow over limestone rocks containing iron pyrites, especially at certain seasons and tides. The river Liffey is an example. Occasionally dock waters contain this gas either from the decomposition of pyrites or from other sources.

The better behaviour of arsenical copper tubes as compared with the brass and nickel-copper tubes is worth noting. In ordinary conditions of corrosion, such as in stagnant or slowly moving water, a rolled 70 : 30 brass free from arsenic would have shown copper deposition long before corrosion had proceeded as far as in the

* At low water-speeds it has often been found that the corrosion of a tube is greatest at the top of tubes near the inlet end, just where these bubbles tend to collect. Such action though important, is much slower than that found with high water speeds.

test, at the end of which no copper deposit was visible. The products of corrosion contained dark coloured sulphides as well as more usual constituents. Stainless iron and the electro-deposited nickel tubes were tested for three weeks only; it is unwise to calculate the loss in a month from the test figure, as the shape of the curve connecting time and corrosion is not yet known; in the case of iron it is not a straight line.

Returning to the consideration of corrosion by ordinary sea water containing entangled air, it must be emphasised that a wide range of copper alloys is susceptible to corrosion of the same order of rapidity as 70 : 30 brass. A set of exploratory tests on binary and ternary alloys with copper as the principal constituent and zinc, tin, nickel and manganese present in various amounts has not, so far, disclosed a material combining all the properties required for a condenser tube alloy. The results on 80 : 20 copper-nickel alloy are particularly interesting in view of the proposed use of this alloy for condenser tubes. In the absence of entangled air this alloy stands up very well, and resembles brass. At 20 deg. C., in the presence of entangled air it behaves fairly well. If the temperature of the test be raised to 40 deg. C., the alloy suffers badly, resembling copper in its behaviour. An alloy containing nearly 70 per cent. of nickel, behaved the best of all the alloys tested; this may be described as a synthetic monel metal made from cathode copper and Mond nickel. It has not yet been tested in tube form.

Part III.—Methods of Protection.

The methods of protecting copper and 70 : 30 tubes from the type of action that has been described in this paper may be considered under two heads, namely: (1) Electrolytic, (2) surface treatment of tubes.

Electrolytic Protection.—As a result of the practical tests it may be said at once that wherever the air-water type of attack is at work, neither protector blocks of steel, zinc, or aluminium alloy, nor the use of separately-generated current in quantities up to 5 amperes per 1,000 sq. ft., have been found to be of any practical value. In estuarine conditions, tubes have been pitted right through in periods of less than a month within an inch or two of the ends (*i.e.*, in a position most favourable for electrolytic protection), notwithstanding that a "protective" current was actually flowing (see Fig. 4). The results of the practical tests were so unexpected that some laboratory experiments were carried out to throw light on them.

The arrangement is shown in Fig. 8. A steel or wrought iron anode is connected to a brass or copper cathode in sea water and to an intermediate electrode. A jet of aerated sea water is caused to play on the cathode, and a stream of sea water is kept circulating through the whole system. The distance apart of the cathode and anode can be varied. The use of the intermediate electrode is to represent the short-circuiting effect of the tube plate and water-box walls in a condenser; it was fixed at a distance of 6 in. from the anode in all cases.

In stagnant and slowly-moving unaerated sea-water it was found that the electro-chemical protection of the copper or brass was practically complete when the distance apart of the main electrodes was 3 ft.

The protective action of the iron anode had disappeared completely at a distance of 30 in. in the case of copper and 18 in. in the case of brass. In condenser practice the protector blocks cannot be placed nearer to the tube end than about 6 in.; hence the protective effect would vanish respectively at distances of 2 ft. and 1 ft. along the tube, and would be only partial at still shorter distances in conditions equivalent to those of the test. Had the conditions been made more severe, as for instance, by the use of sulphuretted hydrogen or a more powerful foaming effect, there is little doubt that the protection would have been still more limited. Further experiments are being carried out on this point. It is, however, clear from the experience already gained that electrolytic protection cannot be expected to extend far into the tube, and as the type of corrosion now under consideration frequently extends for 3 ft. or more into the tube other methods of protection seem desirable.

The Surface Treatment of Tubes.—Experience of corrosion in practical conditions seemed to indicate that the first few weeks, or even days, in the life of a tube was a critical period.

In the first set of experiments three tubes which had seen practical service in condensers and whose lives and behaviour were known, were tested for 28 days in the severe conditions of the jet test. The tubes chosen were a tube which had had a life of thirty-two years, a tube which had failed in eight months on service to the East, and a tube which had failed in four years in service to Brazil. Portions were selected which were free from pronounced local action and covered by fairly thick scales; the first and third tube had failed elsewhere by so-called "dezincing"; the second by scale erosion. At the end of the test all the scales appeared to have resisted completely the action of the jet. Action on the underlying metal, if any, could only have taken place by the slow percolation of air and water through the scale—a type of action far slower than that accompanying scale-erosion.

These tests seemed to show that a thick, dried scale, whether it consisted mainly of zinc compounds as was the case with the two dezincing tubes, or mainly of copper compounds as in the other case, would resist scale-erosion by a jet.

Consequently it seemed desirable to test whether it was the thickness of the scale or the drying process or both together which had conferred on the scale the property of resistance. Accordingly a set of tests was made with tubes from a batch which had already been tested extensively in the jet test, and whose characteristic behaviour was known. The tubes were placed in stagnant sea water for various periods at definite temperatures; they were then removed, and either immediately tested in the wet condition or first dried and then tested. The thickness measurements were made at the end of the experiments after entirely removing the scale by immersion in 0·880 ammonia for a few seconds, followed by washing in distilled water; the losses of thickness are therefore true losses of metal, and are not merely apparent losses obtained by measurements made in the presence of scale. A few of the microscopic pits found opposite the jet in certain cases were too small to admit the steel point of the micrometer, and the figures given in the paper are the greatest losses that could be measured. The pits mentioned, which were examined at a magnification of 60 diameters, were not more than one or two hundredths of a millimetre deeper than the general surface of the tube.

The best conditions for forming a scale that will resist erosion require further tests before they can be regarded as established. It would appear to be desirable from the commercial point of view to ascertain the shortest period of time in which a scale can be formed which would be effective in the dried condition. The tubes could then be treated at any convenient place and stored. The question of deterioration during storage has, however, still to be investigated. The best results obtained so far have been with tubes of 70 : 30 or Admiralty mixture treated in sea water at 40 deg. C. for one week and subsequently dried in the atmosphere for 14 days.

The conclusion to be drawn from the jet tests may be briefly summarised as follows:—

(1) The presence of entangled air in a stream of sea water greatly increases the power of corrosion of that stream on 70 : 30 brass and a variety of copper alloys.

(2) If the temperature of the water be raised from atmospheric to 40 deg. C., the rate of corrosion of copper and some of its alloys, such as 80 : 20 copper-nickel, is increased; the rate of corrosion of 70 : 30 brass is decreased.

(3) The higher the water speed up to 25 ft. per second the greater the corrosion.

(4) The volume and state of sub-division of the air affect the rate of corrosion.

(5) Electrolytic protection of the ordinary type has but a very limited effect in preventing the corrosion. Protection is effective only near the ends of the tubes, and sometimes fails even at these.

(6) The critical period in the life of a tube is its early life when there is little or no sea scale on the tube; at this stage tubes are very susceptible to attack by aerated sea water.

(7) Certain types of sea scale may be very resistant to erosion by air-water jet, and, consequently protect the tube. The scales on old tubes that have stood up well in practice may be hardly noticeably attacked in conditions in which a new tube would be severely corroded.

(8) To some extent the production of scales resistant to rapid air-water attack can be carried out artificially.

(9) Such scales should be useful in tiding the tube over its early critical period and preventing rapid failure. In due course such scale may, or may not, break down owing to chemical changes; in the former case the tube may eventually fail by local pitting or general thinning.

(10) Certain scales even when very thin, *i.e.*, only a few hundredths of a millimetre thick, may be highly protective.

Review of Practical Conditions in the Light of Experimental Results and Experience.

The first question to be decided in studying a plant in which rapid corrosion is occurring is whether or not entangled air is present in the water stream flowing through the condensers. In many plants it is not possible to determine this definitely without making special arrangements; this applies particularly to marine practice. In power station practice it is sometimes possible to do so, and in certain cases the presence of air has been definitely ascertained by the authors. If severe corrosion of new tubes appears in any plant it is, therefore, advisable to collect evidence on this point. The most convenient means of doing so will depend on the particular arrangements of the plant; sometimes an inspection of the outlet water stream is the best available method.

There are three obvious sources of entangled air in an ordinary condenser plant, namely:—

(1) Air leaks in the pipe line, water ends and valves whenever the pressure is below atmospheric pressure.

(2) Air which has passed out of solution in the water owing to local reductions of pressure resulting from sudden changes of velocity in pumps, water-ends, pipelines, &c.

(3) Entangled air already present in the water supply and sucked in with it.

An objection might here be raised that rapid corrosion would be far more frequent than it actually is if the causes were as indicated. It must be remembered, however, that tubes are chiefly liable to air-water erosion in their early life. If scale formation once gets ahead of scale erosion the tube may stand up for a considerable period; even when once started the action may cease if the conditions of flow change. A very elusive factor in the matter is the foaming property of water. It is with a pronouncedly foaming water that the attack is severe, and the foaming must occur in the early life of the tube. A high water-speed and a high vacuum are also necessary in the case of brass tubes. Lastly, it should be remembered that most of the entangled air will pass through comparatively few tubes and only these will be liable to attack.

When the water stream containing air reaches the water-box of the condenser the distribution of the air will depend on the arrangements of the inlet pipe relative to the box, the shape of the latter, the presence of obstructions such as anodes and accumulations of ferric hydrate, the size of the first pass, obstructions in the tubes, &c. As a result it will often happen that most of the air will pass through a comparatively small group of tubes situated at some particular area of the tube plate, as shown in Fig. 6; in other cases the air will be distributed widely and irregularly over the whole pass. In the first case tube failures may be restricted to a small area of the pass and tubes in identical positions may fail time after time. In the second case the failures will occur at different positions at different times and almost anywhere in the first pass.

The procedure to be adopted for such tests has already been outlined. Whenever a fair test has been carried out the result has been to show that there is very little to choose between average batches of tubes of similar composition (70 : 30 or 70 : 29 : 1) made by any of the leading makers, as far as liability to the type of corrosion now under consideration is concerned. The main differences between batches have been in physical properties, such as hardness and freedom from flaws which do not greatly affect it, and in their liability or otherwise to so-called "dezincing."

It occasionally happens in practice that the rapid failure of a comparatively small number of tubes in a new or recently retubed condenser suggests to those in charge that a bad batch of tubes has been used and will give continual trouble unless removed throughout the condenser. Consequently all the tubes are taken out and returned to the maker. When such action is contemplated, however, it is important to remember that it is the early life of the tube that is the critical period, that the number of failures will probably fall off as time goes on, and that precipitate action may result in the removal of large numbers of perfectly good tubes.

The authors wish to emphasise the fact that nothing in this paper is to be taken to apply necessarily to the much slower types of corrosion which cause the penetration of tubes after periods of some years. Such penetration, which may take the form either of an isolated pit or of a porous "plug" of redeposited copper (so-called "plug dezincification"), can occur in the absence of entangled air, a high water-speed or a high vacuum; it is mainly due to slow chemical and physical changes in the scale itself, and may occur in the absence of any serious amount of scale erosion. This type of action is becoming less important commercially in modern conditions than that discussed above, and requires different preventive measures. Still another type of action is that which becomes important when silt and other foreign substances settle on tubes in their early life; corrosion may then be widespread with dispersed local pitting; tubes may fail within a year in special cases, but never so rapidly as with scale erosion in the authors' experience.

CATALOGUES.

Roof Covering Materials.—We have received from Messrs. D. Anderson and Son, Limited, Stratford, Manchester, a brief descriptive catalogue of their various roof covering materials.

Wireless Accessories.—A small and very complete priced catalogue of accessories and spare parts for private wireless installations is to hand from Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E. 18.

Switches and Electric Cooking Apparatus.—The General Electric Company, Limited, Kingsway, London, W.C. 2, have sent us two technical descriptive leaf catalogues of twin-break switches and knife switches, and also an interesting pamphlet describing an electric cooking installation for serving 2,000 people daily.

Motor Starters.—A new design of motor starter, non-automatic and air cooled, for slip-ring induction motors is fully described in a catalogue received from Mr. George Ellison, Perry Barr, Birmingham, who has also sent us a catalogue of control panels for circuits up to 650 volts, in which the starter previously mentioned is included as a component part.

Electrically-Driven Tools.—A priced list of electrically-driven drilling, grinding, polishing and other machines, a slide-rest grinder, and a series of small geared electric motors, ranging from $\frac{1}{8}$ h.p. to 1 h.p., for slow speeds, is to hand from Messrs. Marryat and Place, 28, Hatton Garden, London, E.C. 1. All the designs are neat and convenient for operation.

Sheet Metal Work, &c.—A catalogue received from Messrs. G. A. Harvey and Co. (London), Limited, Woolwich-road, London, S.E. 7, deals with a very comprehensive range of builders' materials, house and office furnishings and utensils, wire netting, perforated metal sheets, stable fittings and utensils, &c. Illustrations, dimensions and prices are given in all cases.

Electric Motors and Starters.—The Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester, have sent us several catalogues dealing with squirrel-cage induction motors of $\frac{1}{2}$ h.p. to 75 h.p., and of starters of the auto-transformer and star-delta types. All the catalogues are carefully prepared, giving the necessary detailed information in clear and convenient form.

Earth Boring.—"Thrust Boring" is the name given to the steadily developing process of piercing the earth, generally in a horizontal line, in connection with the insertion of pipes, cables, &c. Boring is generally associated with some kind of cutting action, but in this process a hole is formed by pressure only without rotation or hammering, a pilot tool being followed by enlarging lengths of rod. The operation is carried out between two working pits, generally 60 ft. apart. The Hydraulic Engineering Company, Limited, Chester, explain the process, tools and gear very fully and clearly in a special catalogue which engineers will find of considerable interest.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

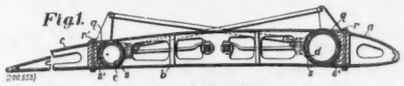
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

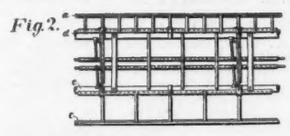
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

200,553. S. E. Saunders, Whippingham. Aeroplane Wings. (7 *Figs.*) March 16, 1922.—The invention relates to an improved aeroplane wing of the kind wherein the centre part is fixed and the leading and trailing parts of the wing are designed to allow of radial movement for increasing or decreasing the effective camber and connected together to a common control, the connection being such as to allow the trailing part or section to be used alone as an aileron for lateral control. According to the invention, the main spars are made of circular section to form parts of the hinges for the leading and trailing portions of the wing. *a*, *b* and *c* indicate the three sections or units forming a

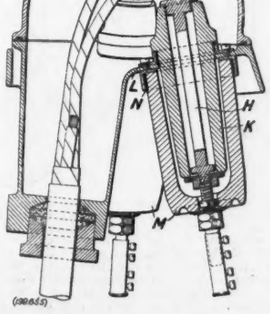




complete wing, the centre part *b* being fixed or braced rigidly to the fuselage of an aeroplane, or to the hull in the case of flying boats. *d*, *e* are the main spars of circular section, which spars are formed of laminated wood tubes, but they may be formed of metal tubes. The main spars *d*, *e* are fixed to the middle section *b* of the plane. The leading and trailing edges *a* and *c* of the plane are built up and connected to the spars by metal clips or strap hinges *q* secured by bolts *r*, and at these hinges the spar is fitted with a metal band *s* and the leading and trailing portions *a*, *c* of the planes with corresponding strips of metal *s1*. By removing the bolts *r* the leading and trailing portions *a*, *c* of the plane can be readily detached from the middle portion *b*. (*Sealed.*)

ELECTRICAL APPARATUS.

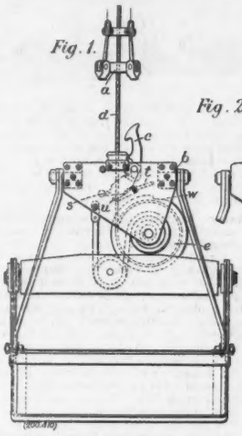
199,655. Johnson and Phillips, Limited, Charlton, London, and W. J. P. Orton, Charlton, London. Outdoor Junction Boxes. (2 *Figs.*) October 13, 1922.—The invention relates to the type of outdoor junction boxes for electric circuits in which the insulators are made in more than one part and in which the part more directly exposed to damage can easily be removed and replaced without dismantling the box, each branch connection being insulated from the box by an inner and outer

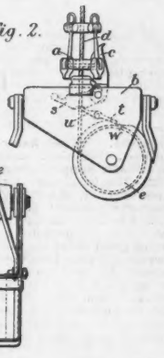


insulator of substantially tubular form, coaxially arranged, the outer insulator which surrounds the inner being readily removable. According to the invention, each outer insulator M is cemented into a metal ring N which is forced into watertight connection with a flange L of the box by a bolt H passing axially through the inner insulator K. The arrangement allows the easy removal of the outer insulator without breaking any joints while preventing the access of moisture to the inner insulator. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

200,410. S. H. Priestman, Hull, and S. Prince, Hessle. Grabs and Excavators. (3 *Figs.*) September 18, 1922.—The invention relates to grabs, excavators and the like intended to be operated by a single rope without the use of stops on the rope. Such grabs have a discharging ring suspended from the jib-head, which is engaged by a hook on the crosshead of the grab in order to enable the crosshead to be held up while the rope is paid out to allow the jaws to open for discharging purposes. It is then necessary to release the hook and to hold the rope in order that the grab may be lowered again with the jaws held open ready to take up a fresh charge. The device employed for holding the rope must become released automatically when the rope is relieved from the weight of the grab, so that the jaws will be drawn together on hauling up the rope again for lifting a fresh charge. According to the invention, a weighted tumbler *s* is used on the crosshead *b* of the grab, this tumbler serving normally to hold out of engagement a double-armed lever *t*, *u*, whose function is to engage with a notch or notches *w* in flanges of the rope barrel *e* when the jaws of the grab are to be held open after discharge. The weighted tumbler *s* is raised or cocked by the pulling upward of the hook *c* when the grab is suspended from the discharging ring *a*, whereupon the double-armed lever *t*, *u* is

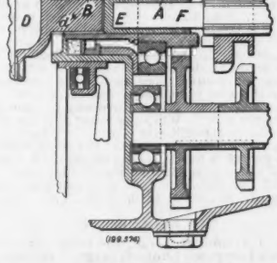




allowed to fall into position for engaging a notch or notches *w* on the rope barrel; consequently when the rope *d* is pulled up slightly after discharge of the grab, the rope barrel *e* is locked and the double-armed lever *t*, *u* is held in a position in which it keeps the tumbler in the cocked position so long as the weight of the grab is taken by the rope. In this cocked position of the tumbler, the hook *c* is free to fall away from the discharging ring *a*, and it does so when the grab is pulled up slightly by the rope, so that the grab can then be lowered freely with the jaws open. When the grab rests upon the ground or the material to be elevated, the slackening of the rope causes the double-armed lever to be released, and this latter in turn allows the tumbler to fall, the tumbler then returning the hook to its position ready to engage the discharging ring again when the rope is hauled up to raise the grab with its load. (*Sealed.*)

MOTOR ROAD VEHICLES.

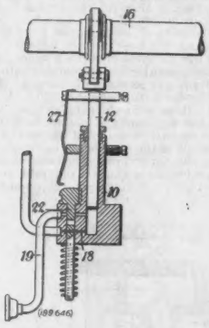
199,574. Sir H. Austin, Bromsgrove. Change-Speed Gears. (1 *Fig.*) May 24, 1922.—The invention relates to change-speed gears for use more especially with automobiles. According to the invention, the first motion shaft A is hollow, at any rate at its outer end, and is internally splined to receive a correspondingly splined boss or short shaft *d* which is rigid with the clutch centre D and is preferably in one piece therewith, the clutch being relatively close up to the gear casing. With such arrangement the bearing B, by which the outer end of the first



motion shaft A is centred in the casing, may be relatively close to the clutch, and in fact may come right over the portion of the first motion shaft which contains the boss of the clutch centre without needing to be of large diameter. The internal splines of the first motion shaft A may act at their inner ends as a stop against the outward movement of a sleeve E which is closed at its outer end and placed within the inner end of the first motion shaft to form the bearing for the corresponding end of the third motion shaft F. (*Sealed.*)

PUMPS.

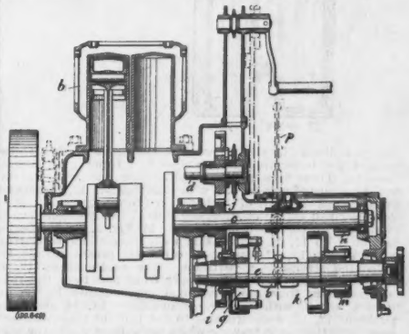
199,646. A. Salisbury, Crewe. Pump. (3 *Figs.*) September 22, 1922.—The invention relates to an improved pump for supplying lubricating oil to the moving and other parts of engines and other mechanism. According to the invention, the pump comprises a cylinder 10 in which reciprocates a ram 12 operated from a crankshaft 16. The ram 12 has mounted adjustably thereon a resilient valve operating member 27 which at the end of the delivery stroke engages a spring-loaded valve 22 and carries this valve during the first portion of the suction stroke to a position to place the interior of the cylinder 10 into communication with a suction pipe 19, and at an appropriate time during the suction stroke releases the valve and permits it to move under the action of its spring to a position to place the interior of



the cylinder 10 into communication with a delivery port or ports 18. The stroke of the valve may be adjusted to vary the output or delivery during the compression or delivery stroke of the ram. (*Sealed.*)

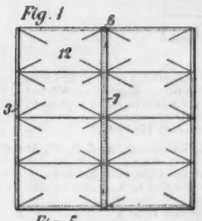
SHIPS AND NAUTICAL APPLIANCES.

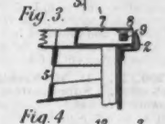
199,849. John I. Thornycroft and Co., Limited, Westminster, and T. Thornycroft, Westminster. (1 *Fig.*) April 7, 1922.—According to the invention, a marine engine set comprises an internal-combustion engine *b* with ahead and reversing gear comprising a lay shaft *e* arranged parallel to the crankshaft *c* of the engine and capable of being coupled to the propeller shaft, separate sets of chain gearing *n*, *m* and spur

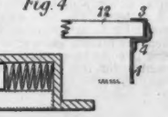


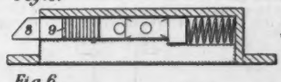
gearing *i*, *j* between the crankshaft *c* and lay shaft *e*, and two similar and interchangeable clutches *g*, *h* that are mounted on the layshaft *e* and are operated by a hand lever *p* and striking gear *o* arranged between the clutches, that member *j* of the spur gearing *i*, *j* which is fixed to the crankshaft *c* serving also to drive a separate camshaft *d* for operating the valves of the engine. (*Sealed.*)

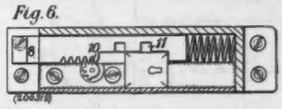
200,319. J. Jolly, Clydebank. Hatch Covers. (8 *Figs.*) June 6, 1922.—The invention relates to hatch covers. The hatch coaming 1 is bounded on two sides by tyzack-section bars 2, and on the two remaining sides by angles 3 secured to bars 4 of tyzack-section. The horizontal faces of the tyzack-section bars 2, 4 afford, in conjunction with a bridle 5 extending mid-way of the hatch, rests for the sections of the wood cover 12, the bridle 5 being accommodated in sockets in the hatch coaming 1. To one of the bars of tyzack-section at one side of the coaming is secured a lug 6 beneath which is received one end of a locking











T-bar 7. Fitted to the opposed bar of tyzack-section is a spring bolt attachment (Figs. 5 and 6), the bolt member 8 of which can engage with a socket 9 on the locking T-bar 7 and enters the socket 9 when the locking T-bar 7 is lowered into position to retain the sections of the hatch cover in position. The bolt 8 is formed with rack teeth 9 which can engage by pinion teeth on a portable key 10. In addition, there is provided a lock 11 engageable by a key having wards which will prevent manipulation of the bolt by any person unpossessed of a key of the second-mentioned type. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

199,562. A. Priestley, Ovenden, Halifax. Steam Boiler Settings. (5 *Figs.*) May 10, 1922.—The invention relates to settings for steam boilers of the Lancashire and Cornish type. The invention consists of an improved form of partitioning the existing return and side flues of these boilers. 1 is a Lancashire boiler, 2, 2 are the furnaces or furnace tubes thereof, whilst 3 is the back chamber or superheater chamber into which the waste heat from the furnace is normally discharged. The flue tubes 2, 2 ordinarily leading from the chamber 3 to the boiler front are partitioned into three separate parallel flues, the central flue 5 having preferably a capacity equal to both the adjacent side flues 6, 7, which are partitioned off at this end from the chamber 3. The flue 5 leads out of the chamber 3, under the boiler 1, towards the boiler front, and partition walls 8, 8 stop short upon approaching a conical midfeather 4 situated opposite to the mouth of the flue 5. The hot gas impacting upon the sloping sides of the mid-

Fig. 1.

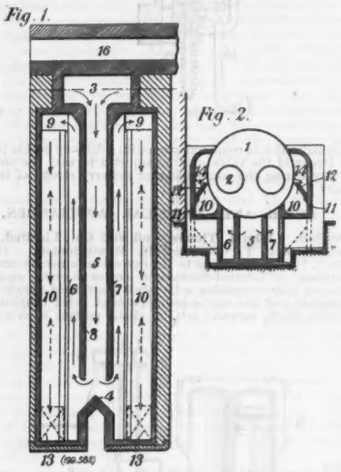
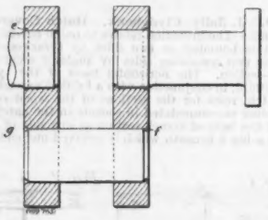


Fig. 2.

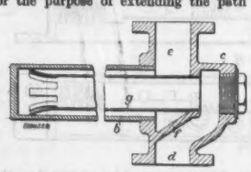
feather, is divided into two separate streams which return to the back of the boiler through the flues 6, 7 forming the second traverse. These flues next rise and communicate with the side flues by means of uptakes 9, 9 with continuations 10, 10 running parallel along each side of the boiler, and formed substantially in the lower half of the existing side flues. The continuations or extensions 10, 10, shown more clearly in Fig. 2, are created by forming a lip 11, 11 on the side walls thereof for supporting inclined slabs 12, 12 leaning or otherwise placed against the boiler and serving as a partition. The continuations 10, 10 upon each side return to the boiler front and form the third traverse, then they again rise and communicate by further uptakes 13, 13 with further continuations 14, 14 above the partitions 12, 12, and returning to the back of the boiler once more, form the fourth traverse which leads directly into the main flue or chimney shaft 16. (*Sealed.*)

199,765. S. Hunter, Junior, Newcastle-on-Tyne, and J. Tindale, Sunderland. Crankshafts. (4 *Figs.*) February 27, 1922.—The invention relates to the manufacture of crankshafts. According to the invention, circular grooves or recesses are formed at the end or ends of the web bore either in the web as at *e* or in



the shaft as at *f*, or in both contiguously as at *g*, and said grooves or recesses may be in the form of a complete annulus or a series of recesses and are filled in by electric or other system of welding so that the parts will be positively united and locked against relative movement. (*Accepted July* 11, 1923.)

200,228. D. M. Nesbit, Leicester, and F. C. Pulsford, Leicester. Superheaters. (6 *Figs.*) April 12, 1922.—The invention relates to superheaters of the kind having a number of duplex or compound tubes connected to a header having an inlet and outlet for the fluid to be superheated and each of which is formed by an arrangement of one tube within another, through which the furnace gases or other superheating medium pass, there being in some cases one or more partitions within the superheater chamber for the purpose of extending the path of the gases.



The invention consists in a superheater of the kind referred to, comprising a header *c* having an inlet *d* and an outlet *e* for the fluid to be superheated, a plurality of duplex tubes *b*, *g* communicating therewith and projecting into the superheater chamber, one or more partitions *f* arranged between the tubes communicating with the header to form divisions in the superheater chamber, each of which divisions contains a plurality of duplex tubes, and supports within the superheater chamber on which the inner ends of the tubes are slidably supported. The invention also consists in a superheater of the above character in which the header is formed from a number of sections, each of which comprises two chambers communicating with the respective tubes of the duplex tube and which is reversible end for end so that the steam or other fluid may pass first through the inner tube and then through the outer tube of each duplex tube, or *vice versa*. (*Sealed.*)

199,672. R. A. Blakeborough, London, and H. Tart, Brighouse. Valves. (3 *Figs.*) December 11, 1922.—The invention relates to the securing of seating rings to valves or valve bodies. In the drawing, *a* represents a face to which it is desired to apply a seating ring, either on a valve or on a valve body. According to the invention, the face is provided with a projecting annular flange a^1, the inner side a^2 of which is at right angles to the part *a*. At a suitable distance from this outer flange a^1, and

Fig. 1.

Fig. 2.

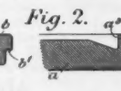
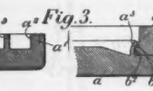
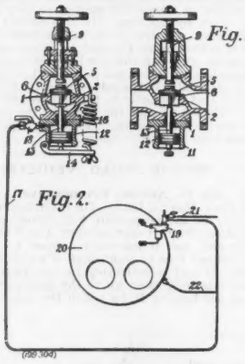


Fig. 3.



on the inner side thereof, a second flange or rib a^3 of relatively narrow width is provided. The seating ring *b* is preferably formed on its outer periphery with a shoulder b^1 adapted, when the ring is applied, to rest upon the outer face of the flange a^1. The inner side of the ring is made, as shown, with a portion b^2 at right angles to its face and with an inclined annular surface b^3, over which the rib or flange a^3 is rolled or spread as shown in Fig. 3, to secure the ring in position. (*Sealed.*)

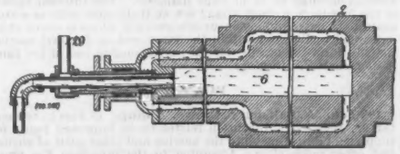
199,304. The Aster Engineering Company (1913), Limited, Wembley, and W. Smith, Harrow-on-the-Hill. Feed Water Supply Control Systems. (6 *Figs.*) September 20, 1922.—The inlet valve for the feed water pump comprises a valve casing 1, the through-way in which is obstructed by a transverse partition 2. The partition 2 is formed with an orifice 6 having a valve seat at its upper end to receive the valve 5. The valve 5 constitutes a control valve. Passing through a packed gland above the valve 5 is a stop 9 which can be adjusted towards and away from the valve to regulate the lift of the latter. Beneath the valve is a cylinder 11. Within it slides a piston 12 having a rod 13 which passes through the wall of the casing 1 so that it can engage the underside of the valve 5. Engaging with the underside of the piston 12 is an abutment on a lever 14 connected to a coiled tension spring 16. The spring 16 holds the piston 12 at the upper limit of its stroke so that the rod 13 holds the valve 5 off its seat. When the valve is thus held off its seat, the feed water surges backwards and forwards through the casing 1 *via* the orifice 6 when the pump is in operation. A pipe line 17 is connected through a cock 18 with the upper end of the cylinder 11, and at its other end the pipe line 17 is connected with a by-pass valve 19 diagrammatically shown in Fig. 2. This valve



is combined with a float mechanism whereby when the water in the boiler 20 is at its normal level the by-pass valve is open and the pipe-line 17 is in direct communication with the hot well through the conduit 21. A branch pipe 22 serves to connect the boiler, below its low water level, with the pipe line 17. The operation of the apparatus is as follows: When the water level in the boiler falls below its predetermined position therein the valve 19 is actuated by its control mechanism so as to shut off the pipe line 17 from the conduit 21. Water under pressure passing through the branch pipe 22 cannot, therefore, pass to the hot well through the conduit 21 and consequently passes under pressure into the upper end of the cylinder 11, thereby forcing the piston 12 downwardly against the tension of the spring 16 to the position illustrated in the drawings. The valve 5 then closes on to its seating and operates in the normal manner as a non-return suction valve and the pump supplies feed water to the boiler. When the water level has attained its predetermined normal height in the boiler, the valve 19 is actuated by its control mechanism to open and the water under pressure in the pipe line 17 is free to escape through the conduit 21 to the hot well and the spring 16 reasserts itself, and, in raising the piston 12, lifts the valve 5 off its seat whereupon the pump ceases to supply feed water to the boiler. (*Sealed.*)

MISCELLANEOUS.

199,242. J. I. Hibbert, Leigh, and Callender's Cable and Construction Company, Limited, Leigh. Heating or Cooling Arrangement for Metal Rolls. (4 *Figs.*) May 30, 1922.—The invention relates to an improved heating or cooling arrangement for metal rolls. According to the invention, a series of passages 2 is arranged near the periphery substantially parallel



with the axis and communicating at the inlet end with a water feed 29, and at the other end of the roll with a central hollow space 6 so that the water flows through the peripheral channels 2 and returns through the central hollow space 6 to discharge at the same end. Conveniently, the neck of the roll is connected with a cylindrical fitting having an outer annular space supplied with a water inlet and communicating with the peripheral channels, while the central hollow space communicates with a central pipe within a cylindrical fitting which pipe serves as a water outlet. (*Sealed.*)

196,022. The Low Engineering Company, Limited, Kensington, London, and A. M. Low, Kensington, London. Mixing Apparatus. (2 *Figs.*) December 14, 1921.—In a mixing machine for emulsions comprising two movable drums *c*, *e* provided with beaters *d*, *e* inter-engaging without contact, the inner drum *e* lies within the periphery of the outer drum *c* to one side of its centre. The beaters of each drum may be arranged

Fig. 1.

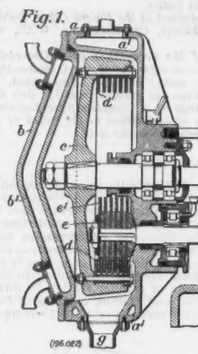


Fig. 2.

in progressive overlapping relation and be so shaped that the beaters of one drum can be withdrawn through those of the other. The drums are driven in opposite directions by separate driving pulleys. The stationary casing *a* and the door *b* are provided with jackets a^1, b^1. The outlet *g* is provided with a valve, while the discharge may be assisted by auxiliary suction or forcing means. (*Accepted April* 25, 1923.)

200,343. A. Blair, Govan, and R. Webster, Govan. Sugar Cane Mills. (4 *Figs.*) June 24, 1922.—According to the invention, sugar cane mills are provided with solid head stocks *a*, *a* bored to receive and fitted with adjustable eccentric bearings

Fig. 2.

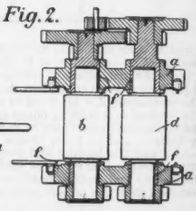
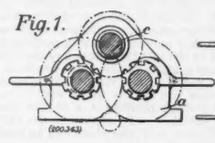


Fig. 1.



for the roller shafts and by means of which the space between the feed roller *b* and the top roller *c* and also between the "megass" roller *d* and top roller *e* can be readily adjusted. By such construction the usual gape in the headstocks together with their covers are entirely omitted. (*Sealed.*)

200,353. J. S. Brae, Glasgow. Storm Valves. (2 *Figs.*) July 5, 1922.—The invention relates to non-return valves, *e.g.*, storm valves, hold suctions, overboard discharge valves and valves adapted to prevent flooding. A valve device, according to the invention, comprises a casing 3, the inlet of which is adapted to be closed by a valve proper constituted by a ball 1

Fig. 1.

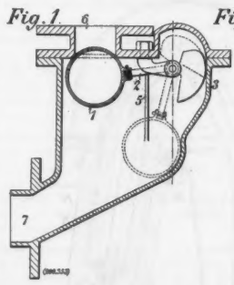
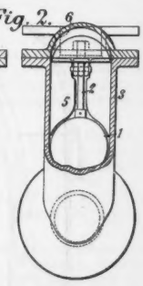


Fig. 2.



of buoyant material, say of hollow metal, carried by a counterweighted arm 2 pivoted within the casing 3, the casing being provided with webs 5 or the like forming a space to receive the pivot, and shielding the ball and arm when the ball is lowered. It is understood that ordinarily the ball 1 is pendent, so that there is a clear passage from the inlet 6 to the outlet 7. If water seeks to return through the outlet, the ball, being buoyant, is at once lifted and pressed against the seat of the inlet opening. (*Sealed.*)

INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships in naval architecture and marine engineering have been awarded by the Council of the Institution of Naval Architects:—*Naval Architecture*: Vickers scholarship (150*l.* per annum for three years), to Mr. C. J. C. Bateson, of Vickers, Barrow-in-Furness; Hawthorn Leslie scholarship (150*l.* per annum for three years), to Mr. John Robson, of Hawthorn Leslie and Co., Hebburn-on-Tyne; J. S. White scholarship (100*l.* per annum for three years), to Mr. Thomas Hamilton, of the Fairfield Shipbuilding and Engineering Company, Govan; Denny scholarship (75*l.* per annum for three years), to Mr. Bryce Crawford, of Dumbarton. *Marine Engineering*:—Richardson Westgarth scholarship (150*l.* per annum for three years), to Mr. Thomas B. Hall, of Richardson, Westgarth and Co., Hartlepool.

ral pipe
outlet.

imited,
ondon.
.—In a
ums *c*, *e*
act, the
e to one
rranged

hat the
e other,
driving
rovided
e, while
forcing

Govan.
g to the
cks *a*, *a*
arings

a

d

f

a

een the
egass"
ch con-
n their

Figs.)
s, *e.g.*,
es and
ording
hich is
ball 1

unter-
being
ve the
wered.
o that
water
, is at
ening.

owing
ering
on of
nolar-
J. C.
thorn
s), to
burn-
n for
rfield
Penny
Bryce
ng :—
n for
dson,